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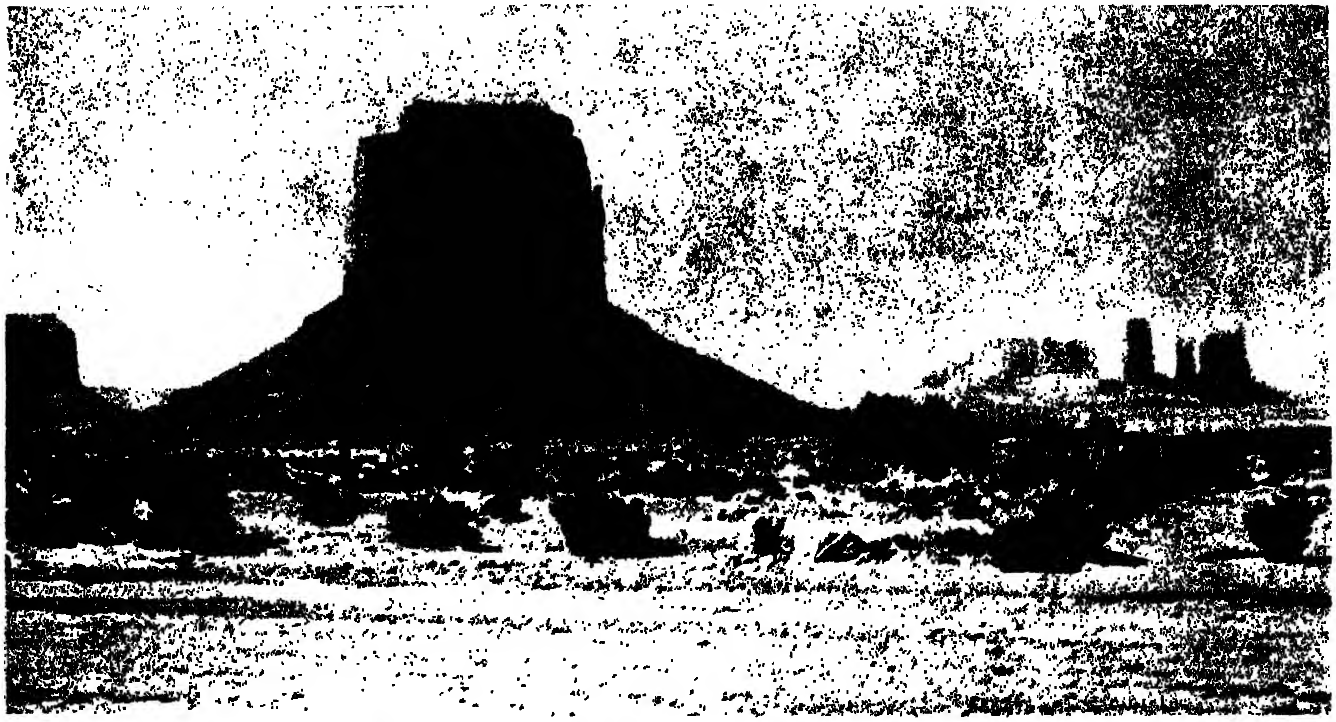
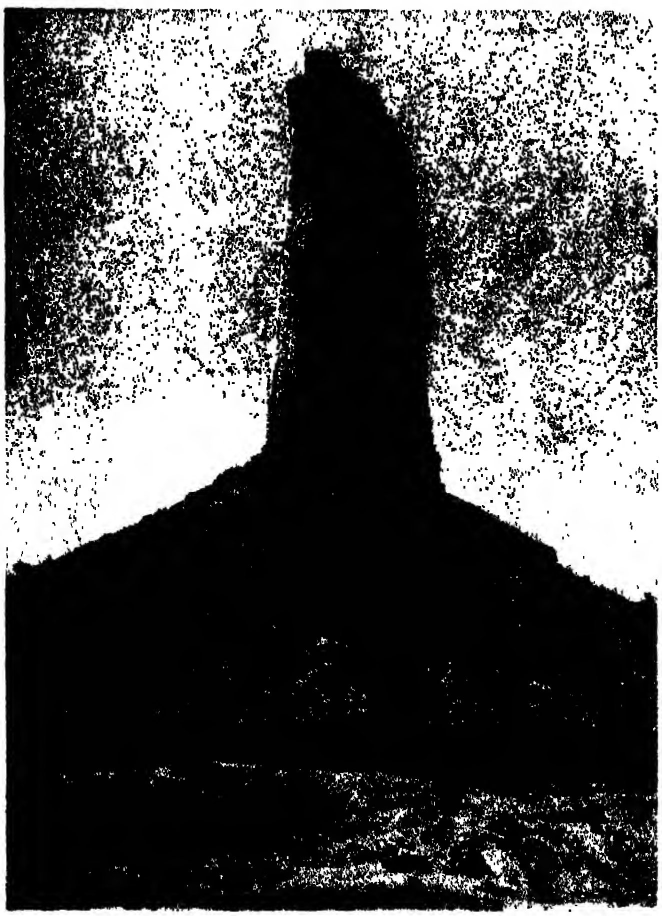
WHEN THE WEATHER ACTS AS ARCHITECT





In Monument Valley, Utah, U.S.A., stand these fantastic examples of natural architecture Great blocks of brick-red sandstone, more than 1,000 feet high, they have been eroded through the centuries by wind-blown sand. Some have been formed into shapes like castles and fortresses (top), others into huge monoliths like the "Wingless Victory" (bottom left) and the "Slim Rock" (right). The upper part of each "monument" is all of one stratum, resting on a base of thinner strata less resistant to weather

THE

WORLD OF WONDER

10,000 THINGS
Every Child Should Know

Edited by
CHARLES RAY

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HOW WE ARE ABLE TO TASTE THINGS

If we were unable to taste things we should not enjoy our food as we do, and it would probably not do us so much good. Yet there are really only four distinct kinds of taste, all others being combinations of these. It is interesting to know that smell is a great assistance to taste, and if we have a cold so that we cannot smell, we are unable to taste our food as well as usual. Here we read many striking facts about the sense of taste.

Just as we see with our eyes and hear with our ears we taste by means of our tongues and the back part of our palates. The real organ of taste is a mucous membrane or wet lining which covers the tongue and hind part of the palate, and is raised up on the tongue into little lumps known as papillae.

All these projections are not alike. The largest are at the back of the tongue, where each has round it a kind of trench. Indeed, seen in section a papilla is like a castle with a moat round. At the bottom of the trench there are glands or ducts through which flows the saliva that mixes with our food and helps it to digest, and in the sides of the trench are buried little organs called taste buds. These taste buds are also found in other parts of the tongue, though there they are less numerous.

The Secret of Tasting

The taste buds are made up of a series of canoe-shaped cells something like the segment of an orange, and they are so arranged as to leave at the surface, where they all meet, a little opening from which a number of tiny hair-like projections jut out into the trench.

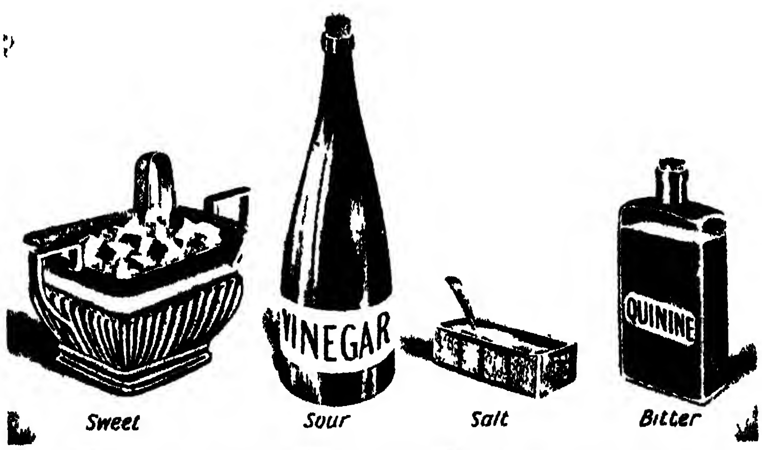
The food we eat is bitten and divided up by the teeth, and as it passes to the back of the mouth some of it falls into the trench where it is partly dissolved. The little hair-like projections of the taste buds coming in contact with the solution convey the impression of taste along the taste nerve to our brain.

There are really only four kinds of taste—sweet, sour, salt and bitter, though a few scientists add two others, namely, alkaline and metallic. Those, however, we need not consider, as they are only combinations of the others. Well-known examples of the four simple flavours are sugar, vinegar, common salt and quinine. All flavours, however complicated, are made up of blends of the four simple tastes, and it is the work of the cook to mix the flavours so as to stimulate all our tastes.

For example, meat has a bitter-sweet taste, and this is greatly improved by the addition of salt. Some people find it still more enjoyable when the sourness of vinegar is added, as when mint sauce is used with lamb, thus blending all four primitive flavours.

Salt Heightens Sweetness

Then, again, sweet articles of food like candies and cake are flat unless they contain a little salt. That is why the cook adds a pinch of salt when making these articles. Also a touch of bitterness often improves the flavour of sweets, as in the case of chocolate. It is by means of condiments, salt, mustard, vinegar and so on, that we adjust and improve our food flavours.



There are only four kinds of taste as shown here, and all the different flavours which we know and enjoy are made up of combinations of these. Typical examples of the four tastes are sugar, vinegar, salt and quinine.

Many drinks, such as tea, coffee and cocoa, depend to a large degree on the bitter ingredients they contain, such as the caffein in coffee. We know how sweet and bitter are combined in marmalade, and sweet and sour in lemonade.

Our habits largely affect our powers of taste. Smokers, for example, as a class are less responsive to sourness than non-smokers, but there is no doubt that people are born with natural differences in regard to taste as in regard to other senses. Children have a keener taste sense than grown-up people, probably because their taste organs have not been spoiled by the too constant use of highly spiced and flavoured foods and sauces.

It is interesting to note that in taste we get no such fusing together of sensations as we do in seeing. If the retina of the eye is stimulated by two complementary colours they are fused to produce the one sensation of white light, but the different kinds of simple flavours can always be detected, and are never fused into one so as to lose their separate characters. When we eat marmalade, for example, we get the sensation of sweetness and also the sensation of bitterness; when we drink lemonade we receive the sensation of sweetness and also that of sourness; and this is true of all foods and drinks.

The tongue is not equally sensitive at all its parts to all four tastes. The back of the tongue is more sensitive to bitter flavour, while the tip responds more readily to a sweet taste, and the sides to an acid or sour taste. The large papillae at the back of the tongue are not all equally alike in producing sensations. For example, if a mixture of quinine and sugar be drunk, one papilla will give us chiefly a bitter taste and another close by a sweet taste.

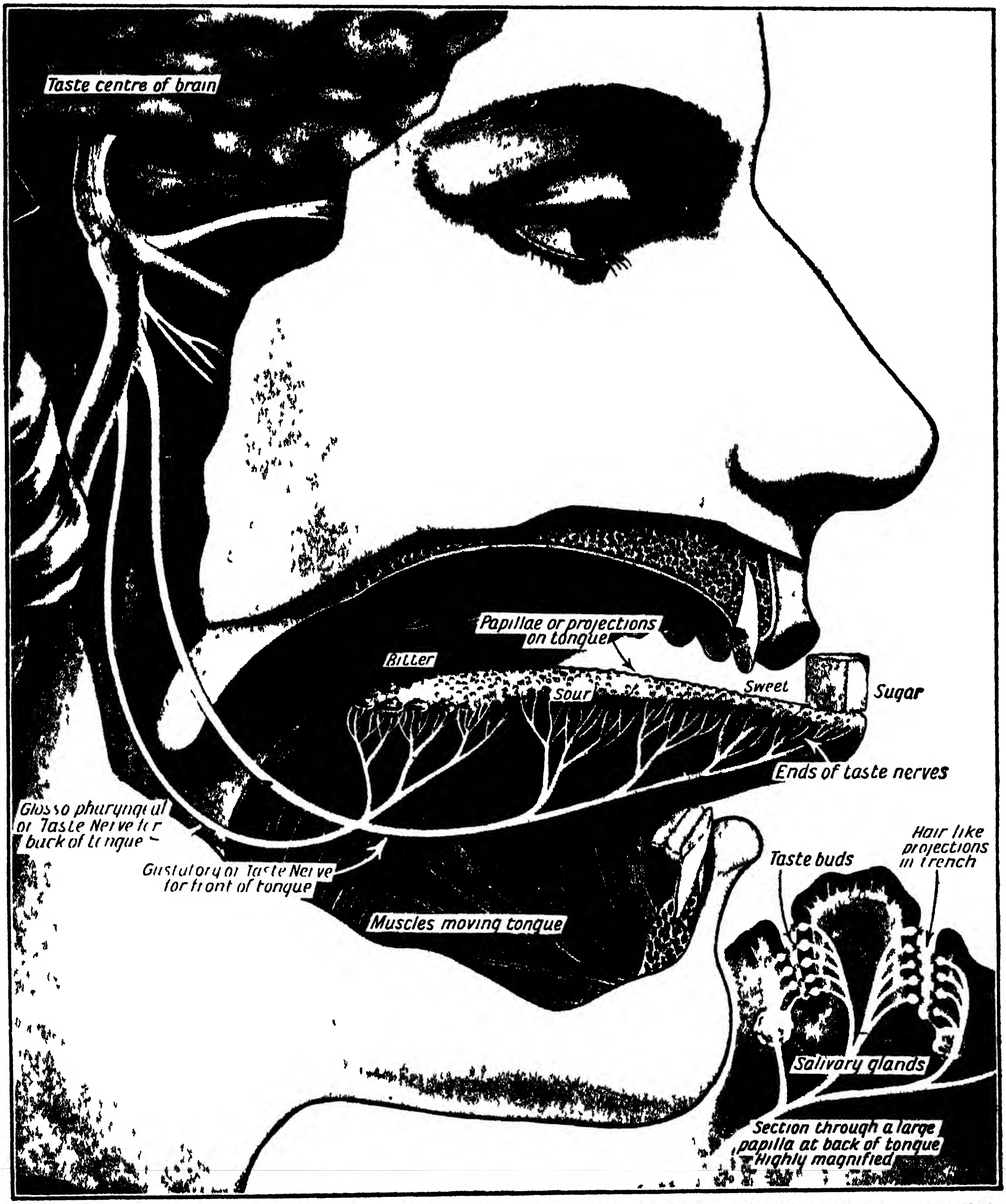
Smell Helps Taste

To go on tasting strongly flavoured substance continuously to some extent deadens the taste organs. That is why professional tea-tasters retain in their mouths the infusion of tea they are tasting only for a moment, and then spit it out. They do not keep it in their mouths long enough to damage their taste organs.

The sense of taste is greatly helped by the sense of smell, and indeed the one is often confused with the other. We frequently fancy we taste a substance such as musk when it is only the organ of smell that is stimulated, and not the organ of taste at all. Even the eye assists the sense of taste, and when red and white wines are taken into the mouth alternately with the eyes bandaged, the taster soon becomes uncertain as to which he is drinking.

Extremes of heat and cold abolish the sense of taste for the time being, and the best results of taste are

WHAT HAPPENS WHEN WE TASTE THINGS



The sense of taste is both useful and pleasant. In this picture we see what happens when we taste things. It is by means of the wet membrane or lining of our tongue and the back part of the palate, or roof of the mouth, that we get the sensation of taste, and this is carried by nerves to the taste centre of the brain. It is the back part of the tongue especially which is used in tasting. The tongue is covered with little projections called papillae, and at the back of the tongue some of these are large, each being surrounded by a groove or trench. In these trenches and at the sides of smaller papillae there are what are known as taste buds, each consisting of a cluster of cells. The cells in the centre of the bud have tiny hair-like projections, and when we take anything into our mouth these hair-like projections are stimulated, and send their message through the nerve to the brain. The ends of the taste nerves are in the papillae. Sweetness is tasted mostly by the tip of the tongue, bitterness by the back, and sourness by the sides

obtained between 50 degrees Fah and 95 degrees Fah We know that when we put something very hot into our mouths by mistake we lose all sense of taste, and when we put a piece of ice on our tongue we are unable to taste anything till the tongue gets warm again

We are quite unable to detect flavours if our tongue is dry and the reason is that to stimulate the taste organs a substance must be in the form of a solution If our tongue is fairly dry and we put a powder upon it, we shall not taste this till some of the grains have become dissolved We can test this for ourselves Let us wash out our mouth with water, allow it to dry by drawing in air, and then place a few grains of castor sugar on the tip of the tongue At first there is no sensation of sweetness —this only comes when some of the sugar is dissolved by saliva

When We Taste Bitter and Sweet

The tip of the tongue is more sensitive to sweet than the back, and here again we can perform a little experiment to prove the fact If we dip a clean paint brush into a solution of sugar and paint first the back and then the tip of the tongue we shall taste the sweetness at the tip before we do at the back On the other hand if we paint the tip of the tongue with something bitter like quinine and then the back we shall taste the bitterness at the back before we do at the tip Even a gas has to be dissolved by the saliva before it can be tasted

An Apple and an Onion

The sense of taste is very delicate We can easily detect the sweetness of a solution in which one part of saccharin is dissolved in 200 000 parts of water and we can detect bitterness when one part of strychnine is dissolved in 2 000 000 parts of water

We have already mentioned that smell is often confused with taste and if the sense of smell be interfered with as when the nose is tightly pinched together, it is difficult to distinguish the tastes of different objects

Let us make an experiment for ourselves We should close our eyes and nip our nose While we can neither see nor smell let us bite alternately an apple and an onion presented by a friend without knowing in which order these are being put into our mouths It will be very difficult to tell whether we are biting the onion or the apple This is why when tasting nasty medicine it is always a good idea to pinch the nose

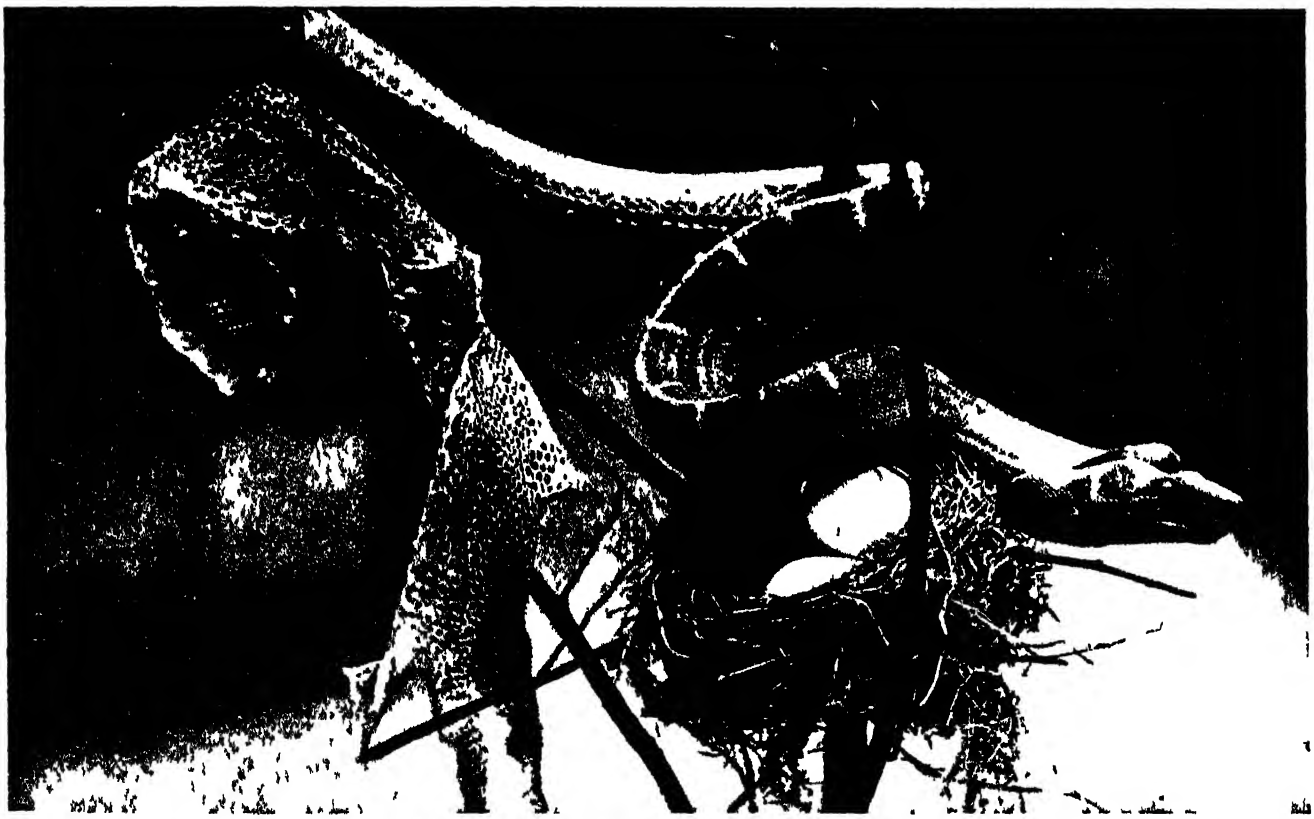
When people sniff a glass of wine to appreciate what they call its taste they are really using their sense of smell the tiny particles from the wine entering their nose and stimulating the nerves of smell

The Effects of a Cold

A person who happens to be suffering from a heavy cold in the nose is quite unable to enjoy the flavour of wine or tobacco, thus showing that smell is combined with taste to convey to our senses the flavours of these substances

In some cases not only the organs of taste and smell but those of touch also come into play If we put a peppermint lozenge into our mouth we taste it, we smell it and the organs of touch give us the sensation of cold so that all three unite to give us the peppermint flavour which is so characteristic

A SNAKE TAKES OFF ITS COAT AND HANGS IT UP



All snakes change their skins several times during the year, and here we see a green boa-constrictor which has just crawled out of its old skin and left it hanging on a tree branch When a snake is going to shed its skin it does so by rubbing itself against the twigs or trunk of a tree or against stones. The skin splits at the mouth, and the snake then glides out, turning the old skin inside out in the process. In other words, it takes its skin off very much as a boy peels off his vest. The snake has no movable eyelids, but there is a convex transparent disc across each eye, covering it as a watch-glass covers the face of a watch When the snake changes its skin the discs over the eyes peel off with the rest and appear as lenses in the cast skin. There is a difference between the casting of its skin by a snake and the moulting of its feathers by a bird. In the bird's case the whole feather is cast at the time of a moult, but in the case of the snake it is really the thin outer covering of the scales that is shed and not the whole of the scales. Some scientists think that the feathers of birds were evolved from the scales of reptiles for reptiles existed on the Earth before ever birds appeared

A GIANT CRAB THAT CLIMBS A TALL TREE

We generally associate crabs with the seashore. One of the interests of a seaside holiday is to look out for crabs under stones and rocks at low tide and to study their queer habit of walking sideways.

In another part of this book we read about our common British crabs and how they are constantly changing their clothes. But all crabs do not live in the sea. There are land crabs which, though they return to the sea when they want to hatch out their young, spend most of their lives far from the sea.

The most interesting of these is known as the robber crab, a name given to it because of its remarkable habit of stealing coconuts. Perhaps we should hardly use the word "steal," for though the coconuts may have been planted by man for his own use, the robber crab does not know that he is doing anything wrong when he seizes this property and uses it himself.

This remarkable crab lives in the islands where the Indian and Pacific Oceans join. It is a large creature, and though it has no shell its abdomen is armoured. It is really a relative of the hermit crabs of our own waters, but the robber crab's tail is not soft and does not need protection.

Nevertheless, it has the instinct of the ordinary hermit crab, and likes to tuck its tail inside the empty shell of a coconut or even an old bully beef tin. It is a remarkable example of how instincts remain when the need and habits have changed.

The robber crab, which breathes atmospheric air like ourselves, and not air mixed with water as its relatives that dwell in the sea do, lives upon coconut. It seizes the nuts that have fallen from the palm trees and with its heavy claws makes a hole and scoops out the white nut. Then when it has emptied the shell it makes use of this sometimes as a tail sheath.

But the robber crab does not merely appropriate the nuts that have fallen from the trees; it actually climbs the tall palms to pluck the nuts, and then when these have been dropped to the ground it climbs down again and seizes its prey.

These crabs are enormously strong and it is said that they can break a man's arm with a nip of their powerful foreclaws as easily as they can crack a coconut shell. Charles Darwin tells us that a specimen which was placed in a strong tin box actually made holes right through the metal and bent this down so as to be able to escape.

One of these crabs which was on show at the London Zoo used to crack the shells of Brazil nuts. That shows us how strong the claws must be, for it is not easy for ourselves to break the shells of Brazil nuts even with nut-crackers.

A robber crab climbing a tree in search of food

In getting at the contents of a coconut the robber crab first tears away the fibre which covers the three "eyes," and then hammers with its claws until a hole is made.

It is said that sometimes when it has perforated an "eye" the crab grasps the nut firmly in its claws and breaks the shell by smashing it on a stone. This, however, is not certain.

The robber crab lives in deep burrows, which it hollows under the roots of the trees, and it carpets its home with fibre stripped from the coconuts.

The change of habit from water to land must have taken the crab a very long time, as this required a change in its breathing organs. Periodically, however, the robber crab visits the sea and there the female lays her eggs. When the young are hatched out they live for some time on the sea coast, spending much of their time in the water, but as they grow older they develop into land animals.

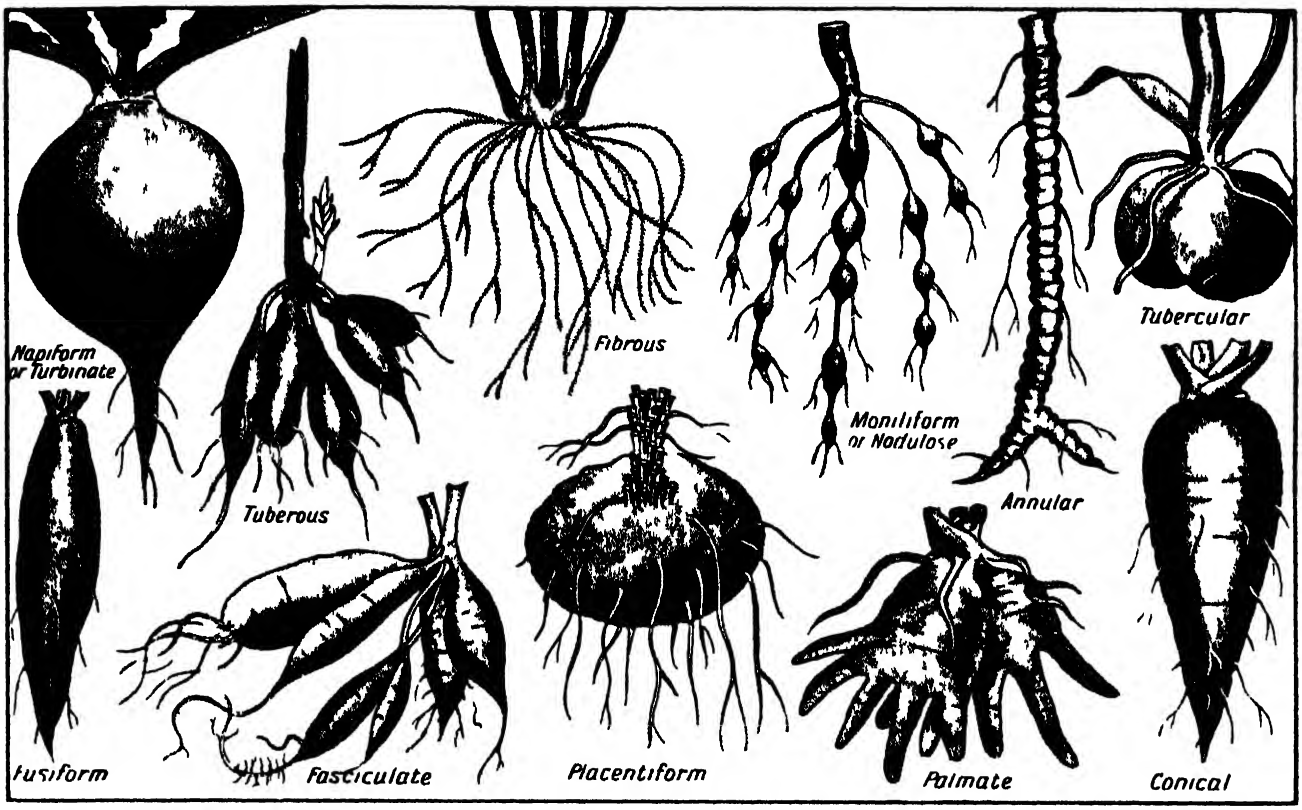
There are other land crabs found in both the Eastern and Western Hemispheres. Certain land crabs inhabit the West Indies, one kind being found in Jamaica. They are generally seen at a distance of two or three miles from the sea, and in the daytime remain under stones or in other sheltered situations. In the spring the male and female crabs pair and soon afterwards they are noticed moving towards the sea. It is there, as in the case of the robber or the coconut crab, that the female lays her eggs.

When the instinct for migration seizes these land crabs nothing is allowed to hinder them. They climb over obstacles and continue on their course till they reach the water. It is a striking sight to see the migration of the land crabs. When the time comes they issue from the hollow trees and the rocky clefts in which they have been living and assemble so rapidly that in quite a short time a great host has been mustered.

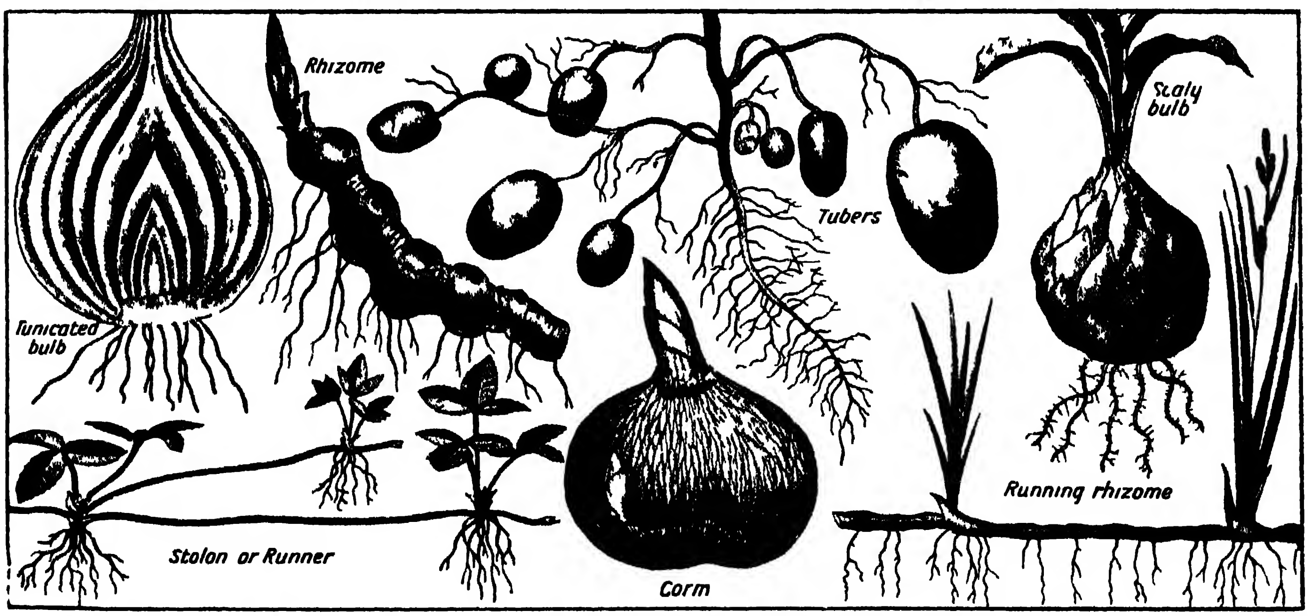
The procession of land crabs to the coast has been seen to cover an area more than a mile long, and 150 feet wide. The way is led by male crabs and the procession goes as far as possible in a straight line. The crabs climb over everything in their path, even over hedges, houses, churches, hills and cliffs.

When the young hatch out of the eggs they are miniature copies of their parents. As soon as the time comes for the crabs to moult their carapaces or shells in the late summer, they return to their burrows away from the sea, and having gone inside close up the entrances to keep out enemies. There they remain till the new shell hardens.

THE DIFFERENT KINDS OF PLANT ROOTS



The roots form a very important part of a plant for they perform two essential duties. First of all it is by the roots that the plant adjusts itself to the soil and obtains the necessary support to grow in a suitable position and further it is through the roots that the plant absorbs water and food solutions for its nourishment. Sometimes the roots also act as storehouses of food for the plant and in that case they take on a specially enlarged form which will enable them to hold large reserves of food. Botanists have divided plant roots into classes according to their form and in these pictures we see a typical example of each form. Napiform means turnip shaped, and turbinate shaped like a top. Tuberous means swollen, fibrous means having fibres, moniliform means shaped like a necklace and nodulose is knotted. Annular is from the Latin word for a ring and an annular root is made up of rings. Tubercular is from the Latin word for a little knob. Fusiform means spindle shaped. Fasciculate is from the Latin word for a little bundle. Placentiform means shaped like a cheese-cake, palmate is like the palm of one's hand and conical is of course like a cone.



In many plants the stem takes on a curious form which is often suggestive of a root, but is not really a root at all. In these pictures are shown some of these root-like stems. A bulb is really a modified leaf bud with fleshy scales partly or wholly buried in the soil. Tunicated means covered with a tunic or membrane, and a tunicated bulb is one composed of numerous concentric coats like an onion. A scaly bulb, of course, consists of a number of scales. A corm, which is from the Greek word for a stem, is the swollen bulb-like base of a stem. Tuber means a swelling, and, of course, our common potatoes are tubers. A rhizome, which comes from the Greek word for root, is a prostrate or subterranean stem giving out leaves at growing points and rootlets from its own surface. A stolon, which is from the Latin word for a shoot, is a trailing branch striking into the earth and rooting, a fresh plant growing from each new root

GIANTS AND DWARFS AMONG THE TREES

We generally think of a tree as something tall and stately, something that can be climbed and that forms a landmark of the countryside In a general way this is true; indeed, the biggest living thing in the world to-day is a tree, one of the giant sequoia trees of California.

There is a group of these known as the Mammoth Grove of Calaveras, and it contains over 90 trees, many of them over 300 feet high and 70 feet or more in circumference round the base of the trunk. One which has fallen, and is known as the Father of the Forest, must have been 400 feet high when it lived, and the trunk is over 100 feet round the base

How many of us, if we had been asked the question, "What is the biggest living thing in the world?" would have thought of answering, "A tree"? We should probably have said "A whale" or "An elephant."

But all trees are not giants. Up in Greenland birch trees are little higher than buttercups Full-grown and perfectly formed trees can be reared in flower-pots, so that they look like models of trees, rather than trees themselves

The Japanese are past-masters in the art of growing these dwarf trees, and many people think they have some great secret which enables them to produce such freaks. But there is no secret at all All that is needed is great patience There are shops in London where we can buy these dwarf trees, often forty or fifty years old, but we should have to give them great attention if we wanted them to go on living as perfect dwarfs.

We may ask why the growing of such trees has become so common in Japan Probably the practice has its origin in the fact that the Japanese have only tiny back-gardens, and they started growing small trees to economise space Some of these trees, perfect in form and shape, and only a foot high, are hundreds of years old.

The method of producing them is as follows. The seed is planted in a small pot, and when it has grown and begun to sprout young shoots these are pinched back from April to the middle of June, the finger and thumb being used for the purpose. This prevents the tree from growing in its normal way During the summer sufficient water is supplied to keep the soil in the pot moist, but in winter the supply is reduced

A dwarf maple tree, 72 years old and less than two feet high

A juniper tree more than 50 years old and only eighteen inches in height

Manure is also supplied twice a month, in spring and autumn, but in summer the soil is not fed. About every third year the tree is re-potted, a third of the old soil being worked away from the roots carefully by means of a sharp-pointed stick. Fresh soil is supplied to take its place. The tree, however, is not transplanted till a larger pot becomes absolutely necessary.

These dwarf trees make excellent table decorations, and look very well on window ledges or tables near windows. The Japanese have brought their use to a fine art, for they make up miniature gardens containing two or three such trees, together with little models of houses, people, bridges, and so on.

Almost any trees can be grown in pots in this way, but the sycamore seems to succeed most surely. The ash and lilac are also good trees to dwarf in pots.

The pot for growing a miniature tree should have a hole at the base, and a few stones or pieces of broken earthenware should be placed at the bottom to help drainage. These trees may be started in ordinary red earthenware pots, but they look their best in the Japanese bowls, which can be bought quite reasonably.

The miniature trees should always be kept in shady positions, for if they remain in the sun for long they are liable to wither and die. Yet they are not delicate in the ordinary sense, and the fact that many of them have lived for thirty, forty, fifty or even a hundred years is a proof that they are hardy. They can be transplanted without injury if care be taken, and the transplanting does not affect their dwarf nature.

All this, of course, requires great patience, and this the Japanese have in no small measure. Hence probably their success in the growing of dwarf trees. Probably, if they started with a sequoia seed, they could grow one of that monster species in a pot the size of a pudding basin.

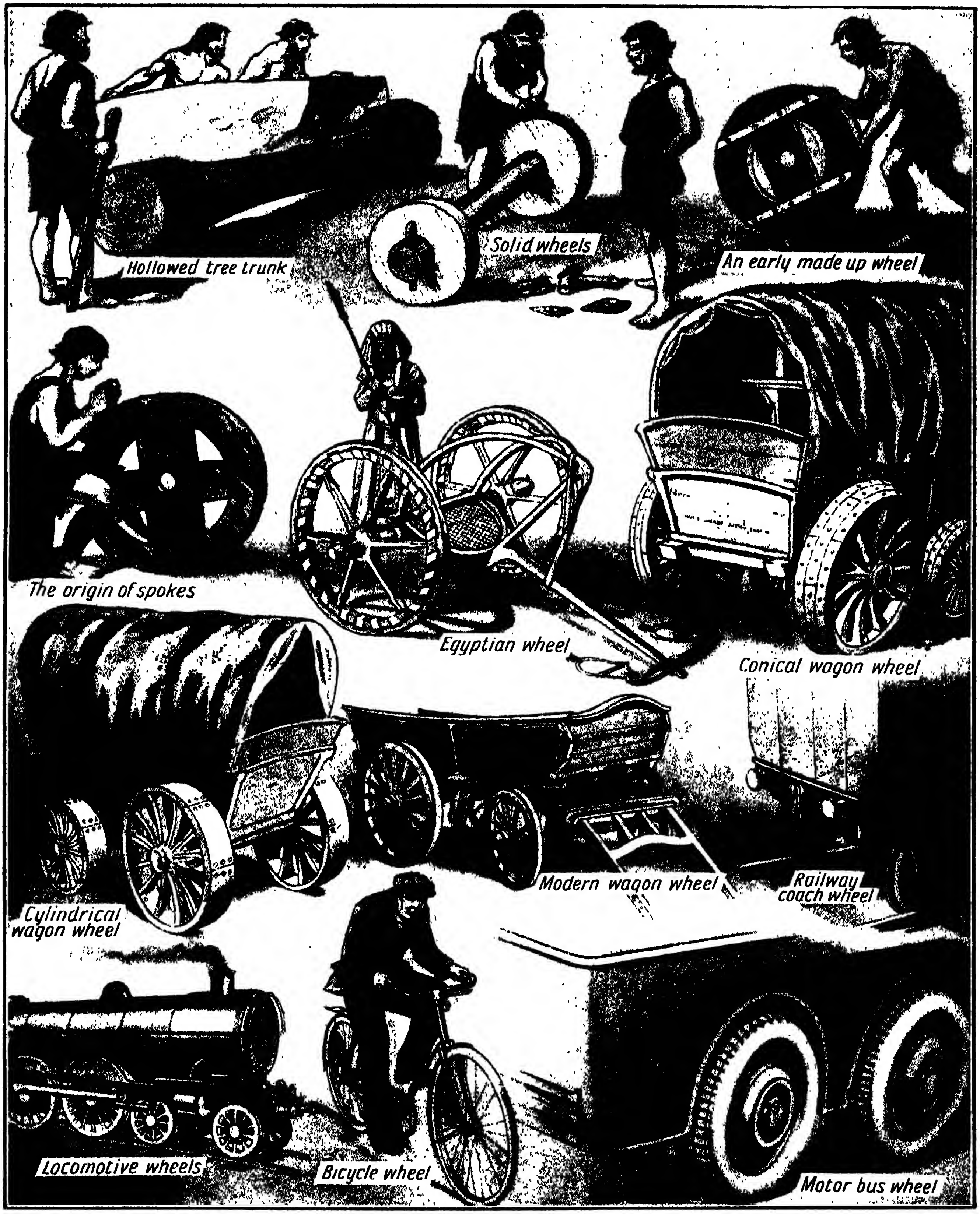
It would certainly be very interesting to see a perfectly proportioned giant sequoia, only a few inches high, standing at the foot of one of the normal goliaths that grow in the Mammoth Grove of Calaveras. The two would look like Dignity and Impudence.

ANIMATED FLOWERS OF THE BRITISH SEAS

Among the strangest and most beautiful of the creatures living in the ocean are the sea anemones They are of many colours, and are of varied forms as can be seen in the pictures on this page, but they all have more or less the resemblance of flowers, and it is for that reason that they have, from the earliest times, been called "animal flowers" They are a lowly type of animal life, and many species live in British waters All shown here are found in the rock pools round our coasts where they may be seen by those who search

Most sea anemones have a more or less cylindrical body, and they fasten themselves to a rock by a sucker device In the centre of the disc at the top is the mouth, and this is surrounded by flexible tentacles, which are swung to and fro in search of food With them the anemone catches such creatures as small crustaceans like shrimps and crabs, tiny molluscs, and very small fishes Almost every kind of animal diet is welcome to the sea anemone, and in a marine aquarium it can be fed on small pieces of meat Anemones produce eggs from which young anemones hatch out, but they also increase by a division of the body If an anemone be cut into halves, each half will develop into a complete animal An anemone has even swallowed a halfpenny bigger than itself, split in two and grown into two anemones

THE STORY OF THE WHEEL FOR TEN THOUSAND YEARS



These pictures show the development of the wheel. No doubt man first used the round trunk of a tree as a roller for shifting heavy objects. Then he would hollow out the middle part of the trunk, and this gave the idea of an axle with wheels at the ends. Probably the first wheels were solid, cut out of one piece of wood. One day a broken wheel had to be repaired, and perhaps this gave the idea of making up the wheel from several pieces. Then to reduce its weight holes were cut out, suggesting the use of spokes. The Egyptians made wheels much like modern carriage wheels. In the 18th century there was much argument as to whether big wagon wheels should be conical or cylindrical, and for a time both were used. During the last century the development of the wheel has been rapid

WHAT THE WHEEL HAS MEANT TO MAN

It is a great pity that we do not know the name of the inventor of the wheel, for if we did we should be able to honour him as one of the greatest inventors of all time. Like other very useful things the wheel probably did not come into being all at once. It was an evolution or gradual development, as shown on the opposite page, but the fact remains that the wheel is one of the most useful devices that man has ever invented, and here we read a great deal about it

If we were asked to make out a list of the greatest inventions we should probably write down such things as the steam engine, the turbine, the power loom, the hydraulic ram, the electric motor, and so on. Yet some of the very greatest inventions that man has ever devised were things far simpler than these complicated machines. In fact, the marvellous machines that do so much of our work to-day and do it so rapidly are only a combination of much simpler inventions dating back to a distant past. Without those simple inventions the marvels of to-day would be quite impossible.

We have already seen what a part the lever plays in modern life (pages 3-5). Another invention which seems very simple and yet is of the most stupendous character is the wheel. Who first thought of a wheel? It is such an obvious idea to-day. Even a child making a cart out of a wooden box places it on a pair of wheels. But there must have been someone who first thought of the idea. We shall never know who did so. He lived away back in the Stone Age.

It is quite probable that the invention of the wheel did not come all at once, and that it was really the result of a kind of evolution. The first burden bearer was probably a woman, for the Stone Age man, like the modern savage of Africa, made his womenfolk do most of the hard work. She had to carry not only her babies, but anything else that needed moving. In Africa to-day the women carry great bundles on their heads, while the man walks along leisurely with no other burden than a few light spears.

Later the sledge was inverted, and on this would be piled the household goods, the cooking pots, and so on, and it would be drawn by thongs over the rough ground. In a bumpy place the articles on the sledge would be shaken off and have to be piled on again, and if the load was very heavy the mere dragging of the sledge across the ground would entail a great deal of exertion.

One day some bright person—we do not know whether it was a man or a woman—thought of the idea of rolling the sledge on tree trunks. Perhaps a fallen tree had been seen rolling down a hill. In any case, it was a great advance and enabled far heavier loads to be moved than was possible without the rollers. After a time rollers of the right length would be cut and used for the purpose, their length more or less fitting the width of the sledge.

But solid tree trunks are heavy things, and the next step in the evolution or invention of the wheel was the hollowing out of the middle part of the roller either by fire or by means of a stone adze. This would have three advantages. It would make the roller much lighter, it would reduce the friction between the roller and the ground, and it would enable the sledge

The forerunner of the wheel was the roller, and here we see a striking example of its use from a model in the Children's Gallery at the Science Museum, South Kensington. The picture represents the transport of a giant statue in Ancient Egypt thousands of years ago

to be kept more conveniently on the rollers between the ends. At last, instead of merely hollowing out the middle of the roller, the wood would be cut away leaving only an axle with a disc at each end, something like a wooden cotton reel. Thus appeared, for the first time in the history of the world, a pair of wheels.

Another great step forward was taken when each wheel was made separately with a hole in its centre through which the end of the axle was passed. The wheel would turn independently of the axle, which could remain fixed to the sledge.

Of course, all those early wheels were solid, the spoke and hub and felloes, or rim, had not yet been invented. One of these solid wheels may have been broken as the result of an accident, and perhaps that gave the idea of building up the wheel out of two or three pieces of wood, instead of cutting it out of the solid. This would simplify matters a good deal, for it is not easy to cut a large wheel out of the solid even if there is available a tree big enough. A solid wooden wheel is rather heavy, and perhaps the next move was to cut two or more large holes each side of the hub to relieve the weight without materially affecting the strength of the wheel.

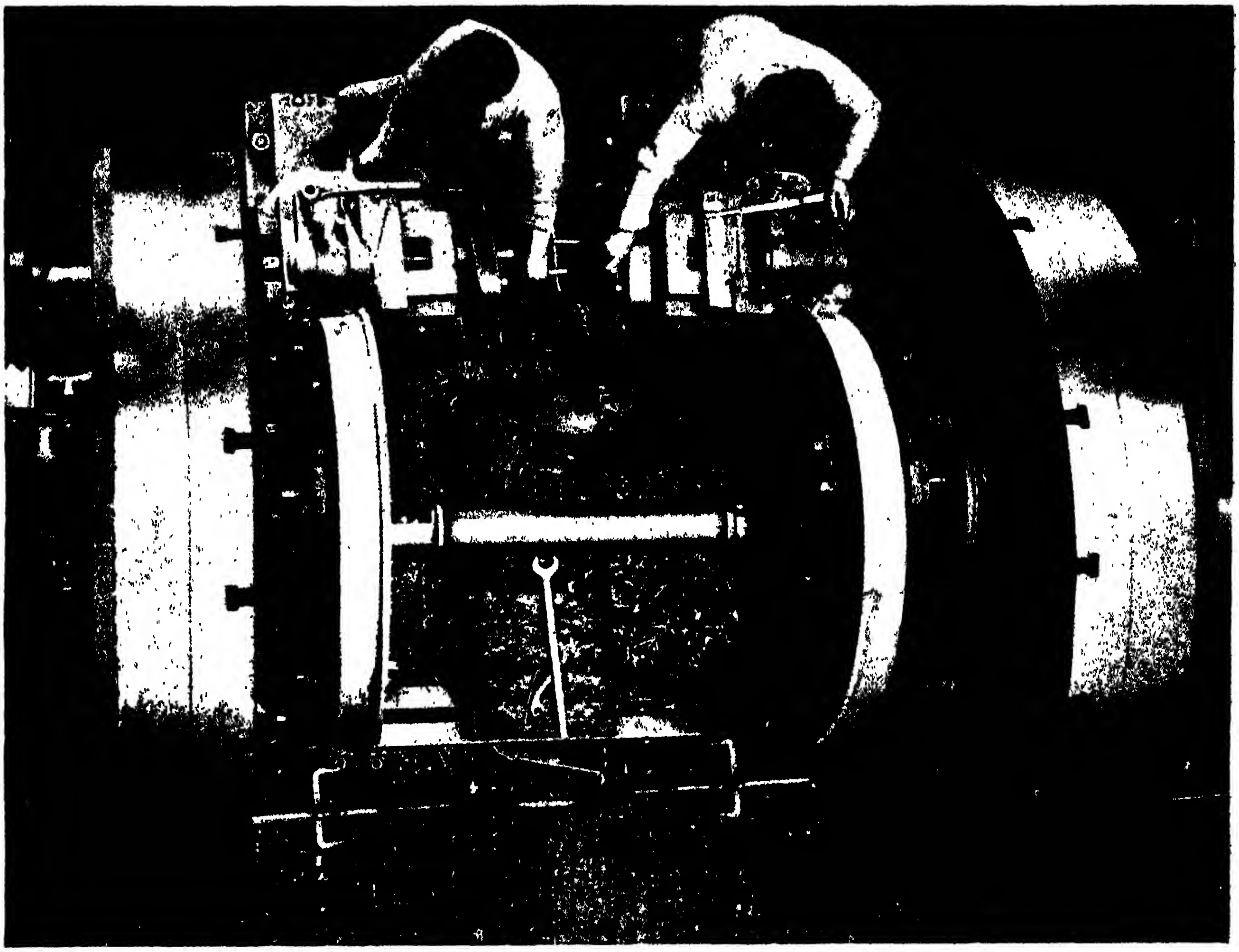
And then a further great advance was made by the invention of the spoke. A prehistoric wheel has been found in which the felloes, or rim, with a diameter are cut out of one piece. Then four other pieces of wood are placed more or less at right angles to the diameter, each forming a kind of brace. They are not spokes in the true sense, but they probably show the origin of the spoke. Solid wooden wheels are still used in some parts of the world, even in civilized countries like Spain, Portugal and Mexico.

The spoked wheel probably originated in Ancient Egypt, and we find on the tombs and other monuments of that country many pictures of wheels that look quite modern. They generally have six spokes, although in some cases there are only four. It is natural that the wheel should have been developed and improved in a flat country like Egypt, where there would be full scope for its use.

Modern life as we know it would be just as impossible without the wheel as without the lever, for in the course of time wheels came to be used not only for transport purposes but for other purposes too, and to-day almost any machine, such as a printing machine or even a watch, is a maze of wheels.

The improvements of the wheel between Ancient Egyptian times and the beginning of the nineteenth century were not very great. With the advent of the railway, wheels came to be made of metal for strength, and in the railway carriage of to-day there is a return to the solid wheel.

But the greatest improvement in the wheel for 5,000 years was the invention of the pneumatic tyre. This again was a case of evolution. The first tyre was of iron bound round the rim of a wooden wheel, partly to hold the felloes together and partly to prevent the wheel from wearing out too quickly. Then came the modern bicycle wheel



Making the huge wheels of a locomotive in the workshops of the Midland Region of British Railways at Crewe. We are looking down on a great lathe turning the steel treads of the wheels, which are four feet three inches in diameter

with its many spokes of very thin wire, and to make travel less bumpy the rubber tyre was thought of

We little realise how jolting a journey on the old roads must have been, especially in the days before springs were invented. The proprietors of the Shrewsbury coach paid in the course of a single year £600 for goods damaged by jolting in their vehicle. A writer says, "I recollect when before springs were put to stage coaches one could not send a trunk fifty miles without having it knocked to pieces"

But to return to the rubber tyre. First of all it was made solid; then to get a wheel-covering that would form more of a cushion, cavities were made in the rubber and the product was known as a cushion tyre. But the greatest advance of all was the invention of the pneumatic tyre, and for this the world has to thank the British

The first patent for a pneumatic tyre was taken out in England in 1845 by Robert Thompson, and a set of tyres was made for a brougham which covered over a thousand miles with their aid But the invention was too early. Methods of manufacture were not sufficiently advanced, and nothing more was done with the pneumatic tyre until 1888 when John Boyd Dunlop of Belfast took out a patent for the form of tyre which is now universal. The pneumatic tyre is used not only for the ordinary pedal bicycles but also for the heaviest motor road vehicles. By abolishing vibration, pneumatic tyres add to the comfort of passengers and reduce wear and tear in the vehicles. A pneumatic tyred coach or heavy lorry has better road holding properties than a solid tyred vehicle and its brakes act more efficiently.

A wheelwright at work on a wooden wagon wheel, which is still made much as it has been for hundreds of years. A new felloe has just been fitted

But even the most efficient pneumatic tyred wheel cannot move easily across rough ground, and to get over this difficulty the caterpillar track was invented. A caterpillar-tracked vehicle is one on which the wheels carry with them their own roadway.

If two wheels be placed in line some distance apart, and a band or belt passed round them in such a manner that when the wheels revolve the band will travel, then the wheel base will be the whole length of the band stretched between the two wheels. A rigid structure is placed between the wheels just above the portion of the track where it rests on the ground. This keeps the band horizontal, and under it the band rolls as the wheels turn. The underside of the track is fitted with shallow projections which grip the ground. The track consists of a number of steel or heavy-rubber treads articulated to form an endless belt.

Caterpillar tracks were invented by an American named Holt in 1907, and were employed in haulage and agricultural work. They were developed for use on military tanks in 1915. Six-wheeled vehicles are sometimes fitted with removable tracks; on roads they travel on their wheels, but on heavy ground caterpillar tracks are fitted to the rear pairs of wheels.

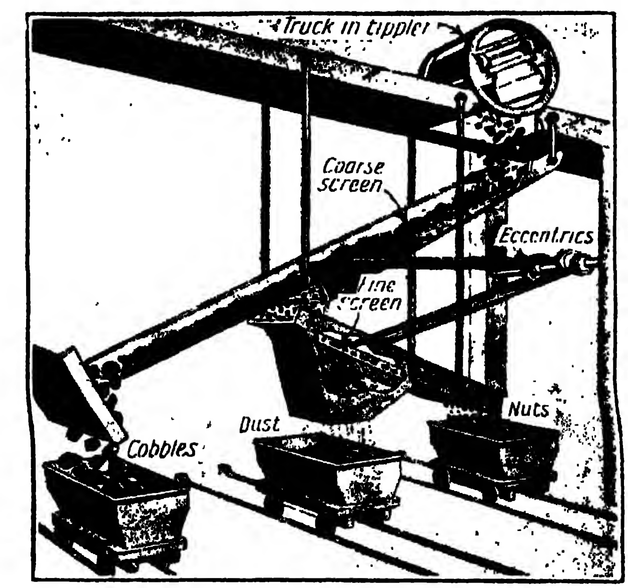
SORTING COAL INTO SIZES AT THE PIT-HEAD

The picture given here shows in some detail how the coal is sorted into different sizes after it has been brought up to the pit-head from the bottom of the shaft.

The wagons containing the coal mixed with a certain amount of shale and other rubbish are run into devices known as tipplers, which take them and then, revolving, turn them upside down and pitch their contents on to a screen or sieve which is placed at a slant so that the coal can run down it by gravitation.

The larger pieces known as cobbles run right down the screen and fall into a truck or on to an endless band, when, after having the rubbish picked out, they are ready for despatch and distribution to the coal merchants.

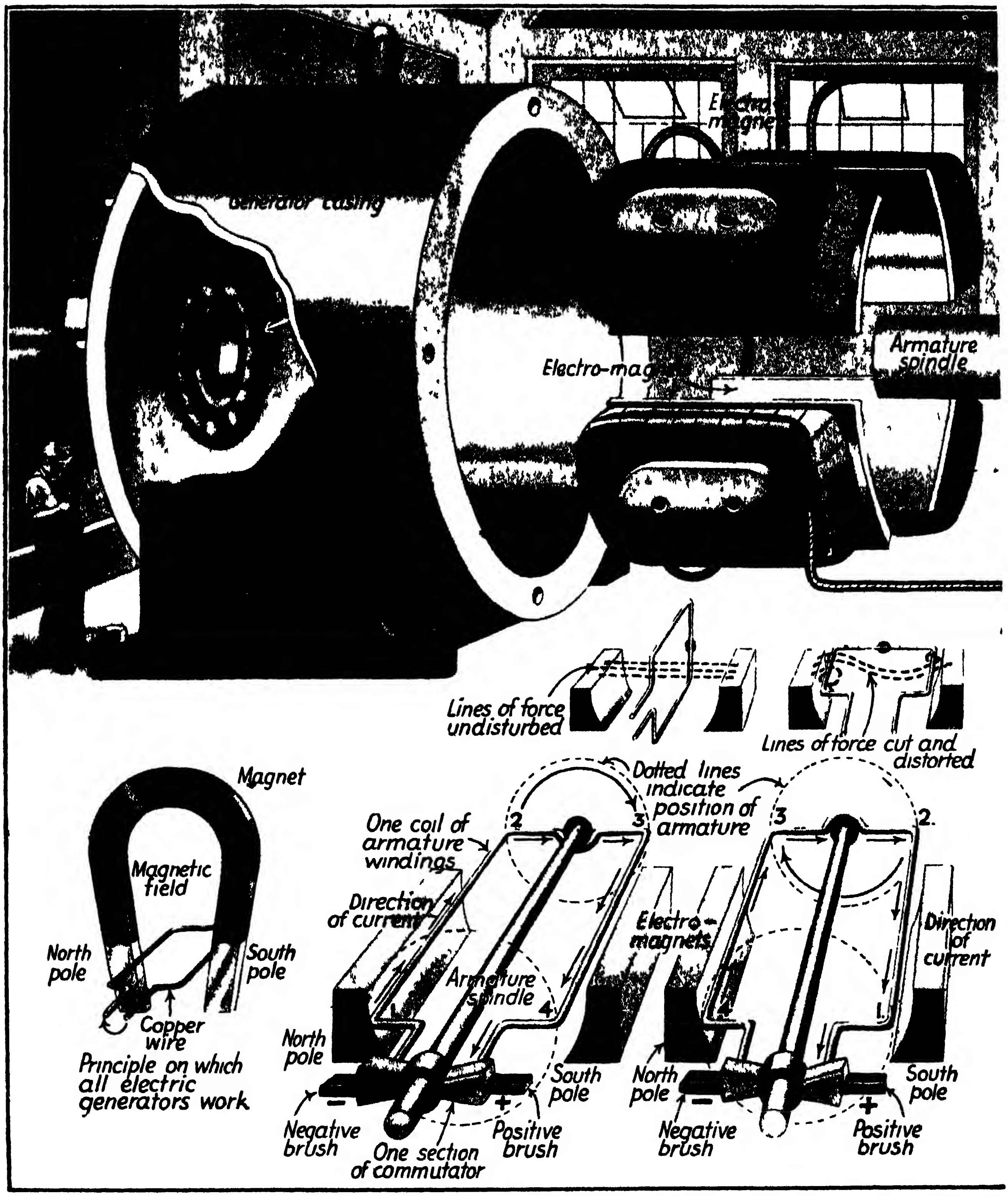
The smaller coal and dust, however, fall through the meshes of the first screen as they run down, and drop on to another finer screen slanting in the opposite direction. There the nuts pass on and fall into a wagon, while the dust falls through the fine meshes and is caught in another wagon. The screens are jerked by rods worked to and fro by eccentrics.



Screening the coal at the pit-head

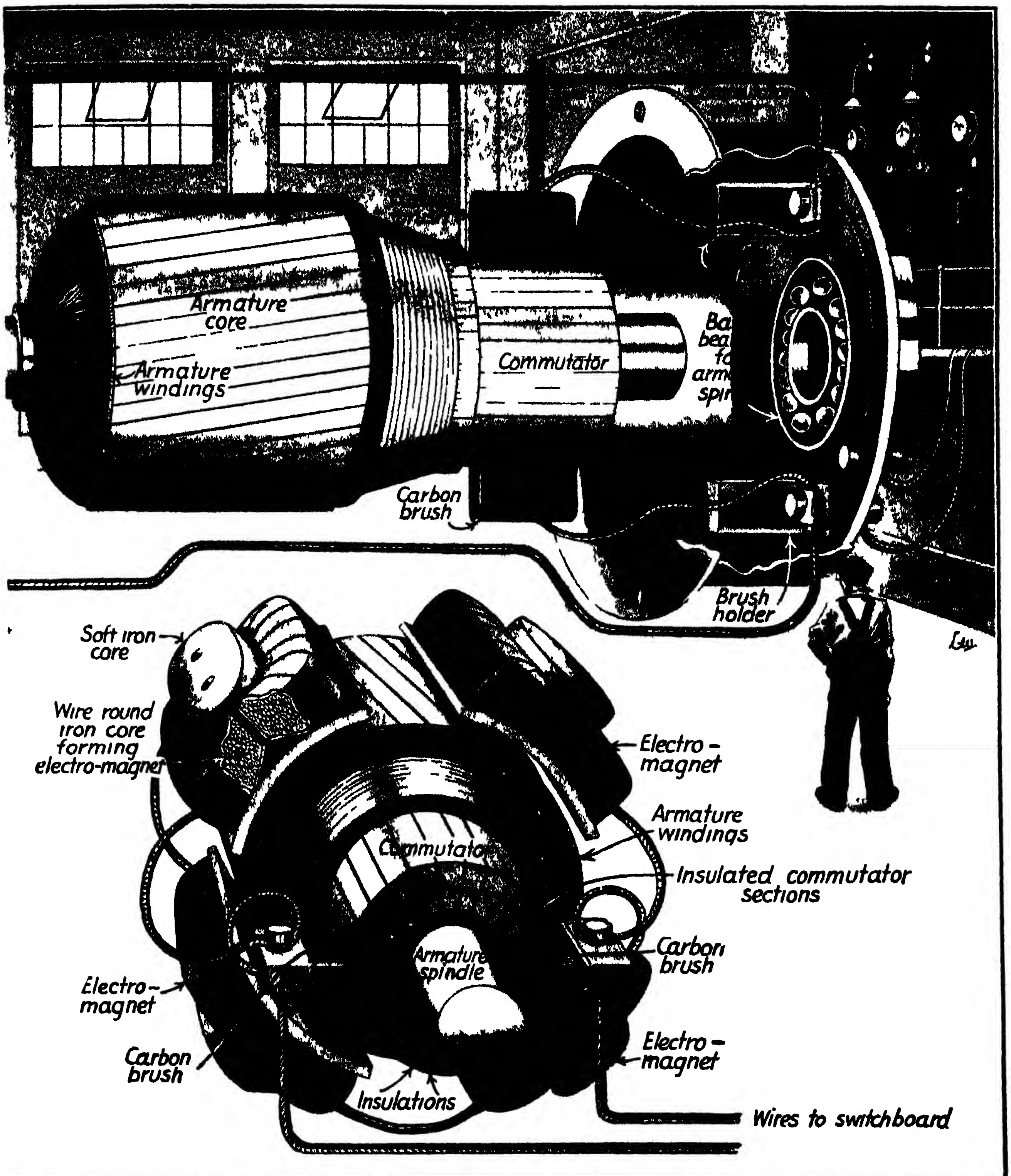
As rubbish could not be picked out of the smaller coal by hand except at a great cost, it is washed to get it clear of shale and other impurities, as illustrated in another part of this book. But often it goes through four or five screenings before passing to the washing apparatus, and it is generally sorted up by this screening into three sizes known as nuts, beans and peas The names were given long ago because of a fancied resemblance to the sizes of the objects referred to and are still used by habit

HOW THE DYNAMO PRODUCES ELECTRICITY



For generating electricity in large quantities for the lighting of cities, the working of machinery, and the driving of tram-cars and trains, a principle known as induction is applied The apparatus that produces the electricity is called a generator, or dynamo At the top of these pages we see the general arrangement of an electric generator but the various parts have been pulled out of the casing so that we may see them When a coil or rectangle of copper wire is moved between the poles of a magnet so as to cut across the lines of magnetic force between those poles, an electric current is produced in the wire The region between the poles is called the magnetic field and immediately the wire is rotated between the poles it cuts the lines of force as shown in the small sketch above and a current is induced or set up in the wire, which flows first in one direction and then in the other The amount of current depends upon the speed with which the lines of force are cut, and also upon their number or the strength of the magnetic field This principle is utilised in the generator as shown in the bottom pictures on this page An armature of soft copper in the form of a U-shaped wire has its ends attached to sections of a commutator, a device for altering the course of an electric current. Each section of the commutator is insulated from every other section, the whole being built up to form a circular commutator, as shown in the bottom right-hand pictures on the next page For the sake of clearness in the explanatory pictures on the left, only one coil of the armature winding and two sections of the commutator are shown When the armature wire is rotated as shown by arrows, between the north and south poles of an electro-magnet, the armature wire cuts the lines of force between the two poles and an electric current is produced in the wire as already explained Part of this current passes

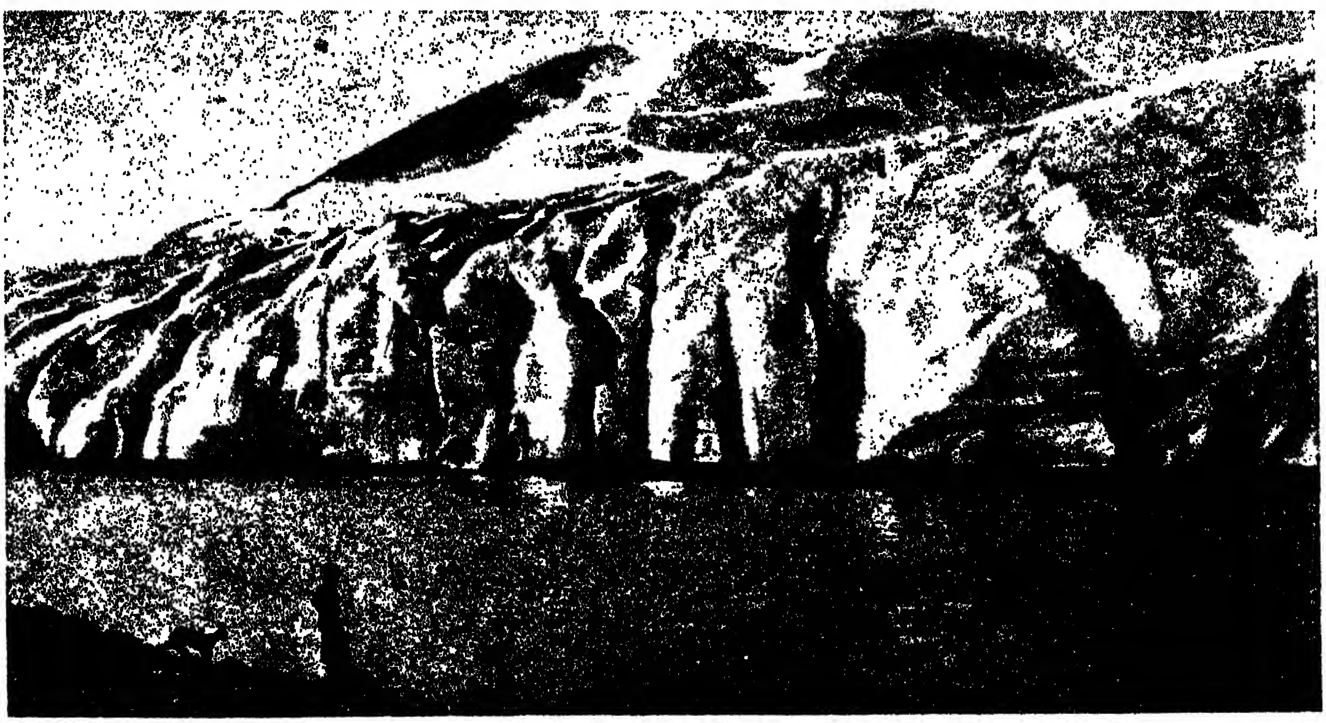
IN VAST QUANTITIES FOR LIGHT & POWER



through the windings of the electro-magnets, producing a strong magnetic field, while the rest of the current is collected from the commutator by what are known as carbon brushes, and is conducted away for use. The wire when rotated cuts the lines of force upwards along 1 and 2 on the sketch, and downward along 3 and 4, producing a positive flow of current. When the wire completes a half-turn as on the right, the lines of force are cut downward along 1 and 2 and upward along 3 and 4, producing a negative current. This is called alternating current, because it flows first one way and then another. When the armature completes the other half of its revolution the direction of the current is again reversed. As a direct current is required in this case, the alternating current in the wire of the armature must be converted by means of a commutator. The two ends of the wire are connected to sections of the commutator which are insulated from one another, and make contact with the negative and positive brushes. When the wire is in the position shown on the left, the current is flowing in the direction of the arrows 1, 2, 3, 4, so that the commutator section on the left (marked with a star) is negative, and the right is positive. After half a revolution the current flows in the direction 4, 3, 2, 1, as shown on the right, the section of the commutator still being negative and positive, as before, and the flow from the brushes to the external circuit remaining the same. The carbon brushes are in contact first with one section of the commutator, then another, connected alternately to the ends of the armature wires in which the current was first produced. In this way the electric current is kept flowing in the same direction. In the right-hand bottom picture we see a generator with four electro-magnets, one being cut away to show the wire windings. We see also the armature and commutator

MIGHTY RIVERS OF SLOWLY FLOWING ICE

A glacier is a frozen river and like rivers of liquid water it flows, though more slowly. Its source is in the snowfields, and if it is a glacier of the mountains the ice moves down a valley between towering peaks. Such a glacier is called a valley glacier. As it moves down the mountain it will often meet a second glacier flowing down another valley, and as in the case of a river of water which joins another, the two frozen rivers then pass on together, forming one glacier. In this picture we see two glaciers in Alaska, uniting to form the Baird Glacier



Here we see the end of a great glacier in the Banff National Park of Alberta, Canada. It is what is known as a high latitude glacier, and such a glacier contains much more ice than a valley glacier. In the far north the snow gives rise to fields of ice, which often lie on plains or plateaux, and when the ice begins to spread it moves in all directions from its centre. Such a glacier may be nearly circular in form, and is often called an ice-cap, or ice-sheet. Greenland is covered by a huge glacier of this type

WONDERS of LAND & WATER

RIVERS OF ICE AND THEIR WAYS

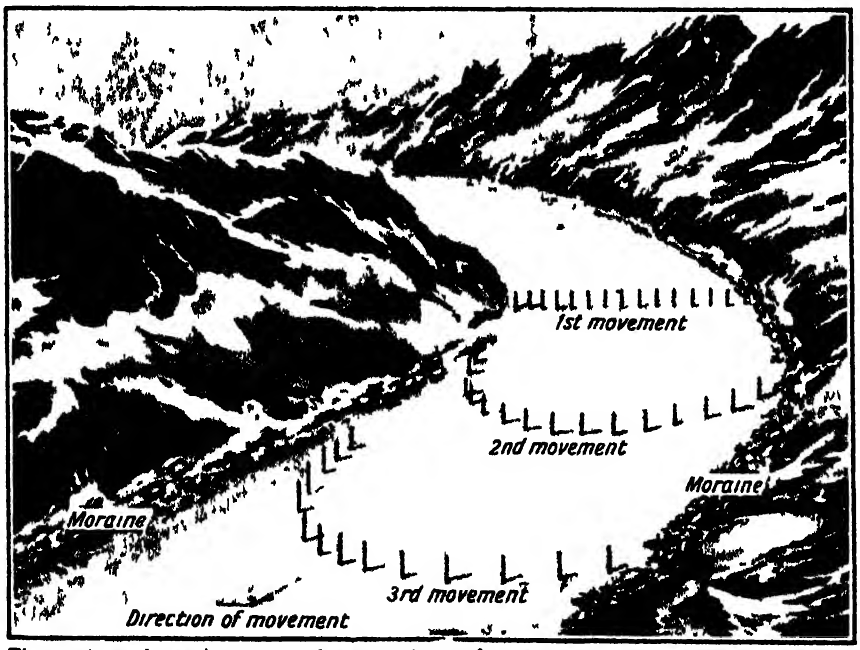
When we speak of a river we generally think of a stream of flowing water But there are hundreds of rivers which do not consist of running water at all. They are found high up in mountains and in the North and South Polar regions. There the cold is so great that the rivers of water are frozen into ice, and we give them the name of glaciers The name comes from the French word for "ice." Of course, these frozen rivers travel much more slowly than rivers of liquid water, but they are nevertheless moving all the time On these pages we read many interesting things about the glaciers

WHAT happens to all the snow that is constantly falling on the tops of mountains? We know that when rain falls on the uplands a certain amount of it sinks through the soil to lower levels, while the rest flows down the surface in streams and brooks which join till at last they form a river, and thus the water eventually reaches the sea As the poet Swinburne says "Even the weariest river winds somewhere safe to sea

But water can easily do this, for it is a liquid Snow however, is a solid, and it can neither sink through the soil nor run away quickly like water Yet it obviously cannot go on accumulating in the upper parts of mountains or with frequent snow storms they would get higher and higher Well this is what happens

Ice from Snow

We have already seen (page 295) that snowflakes if they are just at or below freezing point can be pressed together so as to form a solid mass This is known as regelation As more and more snow falls on the mountain it presses on the layers below till at last the pressure is great enough to transform the snow first of all into a compact mass known as névé or firn and then, as the air is squeezed out, into clear blue ice



This picture shows how men of science know that a glacier is moving, and that the middle part moves faster than the sides Stakes are driven into the ice in a straight row across the glacier, and after some weeks, or even months, the stakes are found to have moved forward, and instead of a straight row they now form a curved line, as seen here Stones that are loosened from the mountain sides form lines called moraines

As the ground in the uplands is more or less inclined at an angle, gravitation **sets the ice moving downward even though the slope may be very gentle But the movement of a glacier is very different from that of a river It is true that one large glacier in North Greenland is said to advance at the rate of 100 feet a day, but most glaciers move at a very much slower** rate The speed of the Mer de Glace in Switzerland has been carefully measured and it has been found to travel at the rate of from 20 to 27 inches every 24 hours at the centre and from 13 to 19½ inches at the sides

Of course, the path of the glacier is not a straight line It winds about and sometimes there are rocky ledges to pass over corresponding to those which cause waterfalls in rivers How is a solid brittle substance like glass enabled to adapt itself to such an irregular course?

Well, men of science used to think that the ice of the glacier behaved like a plastic or viscous body, such, for instance, as dough or thick treacle "A glacier," declared Principal James Forbes, "is a plastic mass impelled by gravity, having tenacity sufficient to mould itself upon the obstacles which it encounters, and to permit one portion to slide past another without fracture, except when the forces are so violent as to produce discontinuity in the form of a crevasse, or more generally in the bruised condition of a mass so acted upon

But Professor Tyndall at once pointed out that this theory could not be the right one for ice even at melting point was a rigid crystalline body incapable of bending and therefore unable to flow and to mould itself to its channel Dr Tyndall suggested another explanation, which is now recognised as the right one

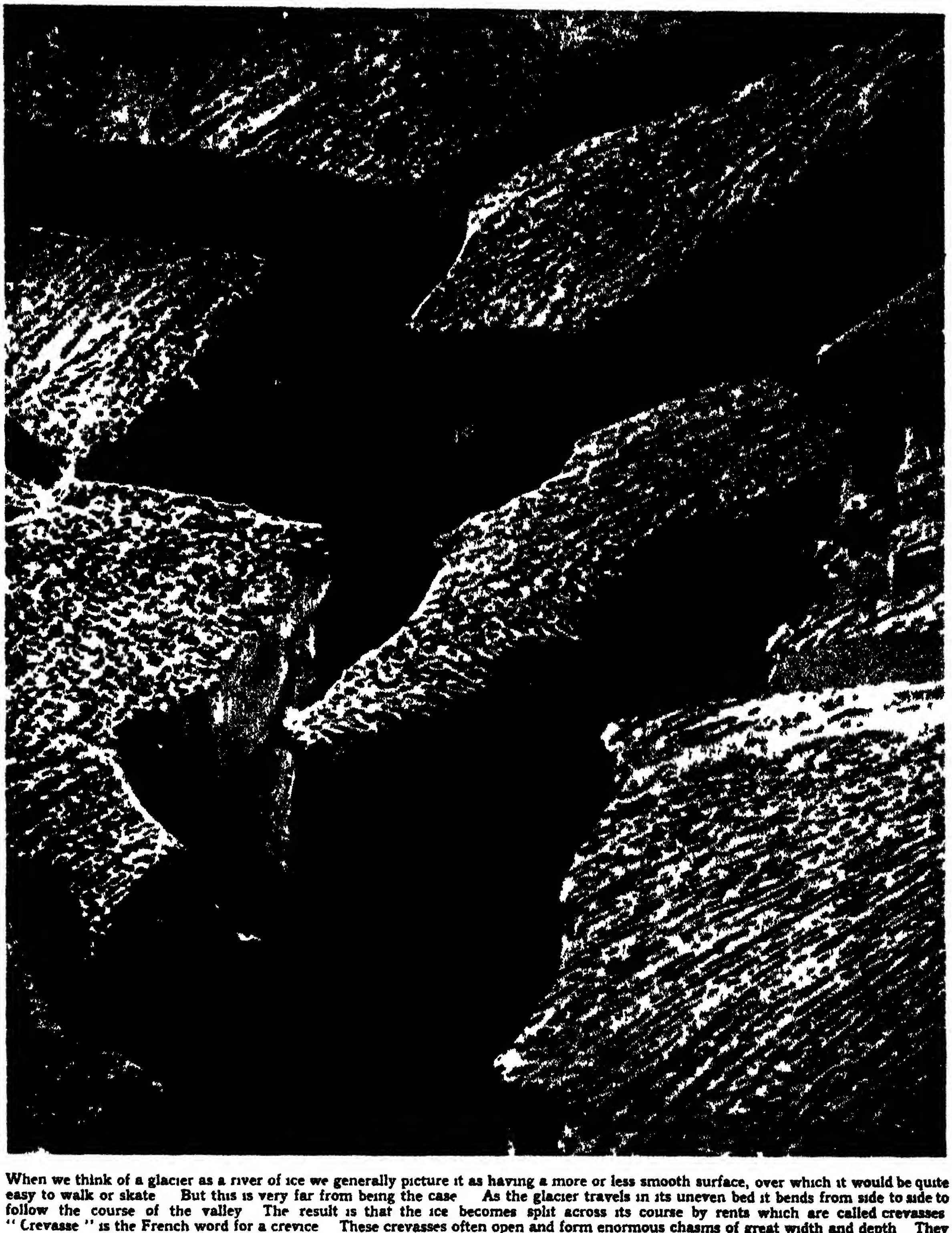
As a glacier flows down its channel the ice is broken and cracked incessantly, the crevasses often forming huge cavities When the sun shines upon these cracks and cavities the ice is brought to melting point, so that the faces of the cracks are covered with a thin film of water Then as the glacier moves and the sides of the fractures are pressed together the ice becomes once more continuous by regelation In this way the brittle mass of ice gives the impression of being plastic, though it is not really so

Tell-tale Stakes

Experiment has shown that the centre of a glacier moves faster than the sides, for if a row of stakes be set across the glacier from side to side in a straight line, in the course of time the line becomes curved in the direction in which the glacier is travelling, proving that the centre travels faster than the sides The centre of a glacier is often a little higher than its sides

The slow rate at which a glacier travels from the regions colder than freezing point to the warmer valleys prevents the river of ice from being turned into a river of water, for so little of the ice

MAMMOTH CRACKS IN A RIVER OF ICE



When we think of a glacier as a river of ice we generally picture it as having a more or less smooth surface, over which it would be quite easy to walk or skate But this is very far from being the case As the glacier travels in its uneven bed it bends from side to side to follow the course of the valley The result is that the ice becomes split across its course by rents which are called crevasses "Crevasse" is the French word for a crevice These crevasses often open and form enormous chasms of great width and depth They are not, as many people think, little chinks which can be quite easily stepped or jumped over The real character of crevasses can be seen by this remarkable photograph showing such fissures in an Alpine glacier Boulders and stones that fall from the mountain, slip through these crevasses and are carried along by the glacier in its ever-onward course As they rub over the rocky bed they wear it away Of course, when the sides of these yawning crevasses are pressed together at another bend or change in the glacier's course, the sides freeze together by regelation, as described on page 295, and the crevasse disappears

melts day by day where the glacier ends that the water easily runs away or evaporates without forming a large river

This, of course, applies to the glaciers found in large mountain ranges like the Alps, the Himalayas, and so on In the Alps alone there are nearly 2 000 glaciers, and only one is as long as ten miles Fewer than forty have a length of five miles and the great majority are not more than one mile long Some are only a few hundred feet wide but one or two are a mile in width At the thickest parts these Alpine glaciers are only a few hundred feet deep

Glaciers have different names according to their characters Those found in the Alps and similar places are known as Alpine glaciers, while those of the Polar regions, whose bed is much steeper, are known as high altitude glaciers Then at the bases of mountains when several valley glaciers unite at their ends, they form what are known as Piedmont glaciers There is a Piedmont glacier in the St Elias range of Alaska, 70 miles long and nearly 25 miles wide

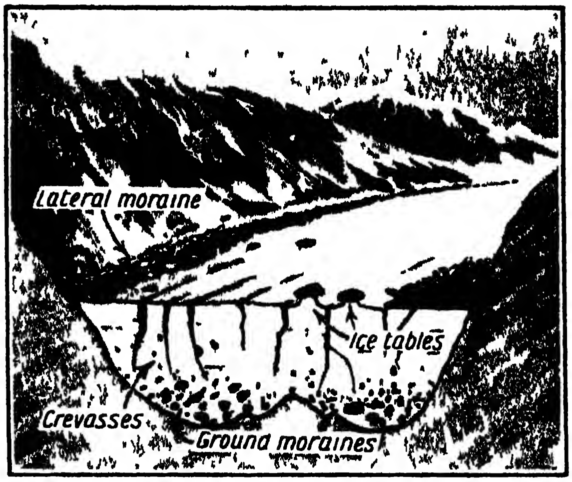
Sometimes as in North Greenland, a glacier will fall over a precipitous cliff 2,000 feet or more in height Then it is called a cliff glacier When in high altitudes a large field of ice spreads in all directions from its centre, forming a kind of circular glacier, it is called an ice-cap or ice sheet The most common form of glacier however is the Alpine glacier

Sometimes when an accident happens in the Alps and the victims fall into a crevasse and are killed, it is years before their bodies are found and then at a place far removed from where the accident occurred for the bodies are frozen in and carried with the ice to the end of the glacier In 1820 on the highest part of a glacier near Chamonix an avalanche carried over a precipice and buried the leaders of a mountaineering party who were ascending Mont Blanc They were only 1 000 feet from the summit More than forty years later some guides crossing the lower part of the glacier, found the remains, with the knapsacks of this party This was at a spot 10,384 feet lower than where the accident occurred, so that the journey of 41 years had been at the rate of 253¼ feet per year

In 1846 parts of a knapsack which had been lost ten years before in a deep crevasse were found with the contents in good condition The discovery was made at a spot 4,300 feet lower than where the knapsack was lost

A few years ago some scientists threw into a crevasse on a glacier at Pontresina a strongly made brass box containing a number of documents The box is to be recovered at the end of the glacier when a calculation will be made as to the speed of the ice It is reckoned that the box will not be recovered for a century or a century and a half A note inside asks the finder to send it at once to the authorities of Pontresina The glacier is believed to be moving at the rate of about two-fifths of an inch per hour

Glaciers do a great deal of work in the transporting of rocks and other material but of this we read in another part of this book The rocks loosened from the mountain and falling on to the sides of the glacier form closely-packed lines of material called moraines, and when two glaciers meet the inside moraines of each join and form what is known as a medial moraine Those at the sides are known as lateral moraines, and when the matter is all deposited at the end of the glacier it is known as a terminal moraine Moraine is a French word derived from the Italian word mora, a heap of stones We have adopted the French word



A cross section of a glacier, showing the crevasses or cracks, the ice tables, the lateral or side moraines, and the ground moraines caused by stones and rocks that have fallen through crevasses Ice tables are large stones on pillars of ice the ice all round having melted as the glacier travelled

HOW THE GREASY RING ROUND THE MOON IS CAUSED

We often see a kind of misty light round the Moon looking something like a circular luminous cloud The popular name for it is "the greasy ring round the Moon," and we may perhaps wonder what causes it

Men of science call this appearance a 'halo,' and, although so far back as the seventeenth century a French scientist named Mariotte stated what the true explanation was, his words were long neglected, and other explanations, since proved to be wrong, were accepted

In recent times men of science have come back to Mariotte's explanation, which has been proved to be true by careful observations made on mountain tops and in balloons

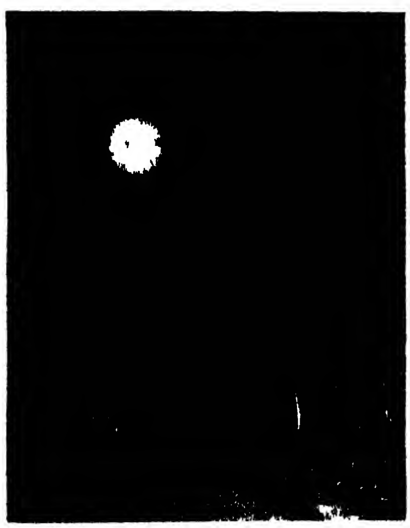
When these haloes or greasy rings are seen the sky is more or less covered with a thin veil of cirro-stratus or alto-stratus clouds These clouds which are very high up, are made up of minute snowflakes and small ice crystals, sometimes called "ice needles"

As the light from the Moon passes through these cloud wisps it is refracted and reflected by the particles of ice with the result that the Moon appears to have round it a misty halo

The greasy ring round the Moon is caused in somewhat the same way as haloes sometimes seen round the Sun

But while a halo is due to refraction and reflection by ice crystals, another phenomenon of a similar character known as a corona is due to the light being seen through drops of water all more or less of nearly equal size

The diameter of the corona depends upon the size of these tiny drops of water It becomes smaller as they increase in size The light passing through these drops of water is modified by what is known as diffraction Diffraction means that the light when it passes through small apertures becomes bent and broken up into its various colours We may get a diffraction effect by looking at a distant light through a bird's feather, holding the feather up before our eye Haloes and coronas seen round the Sun are usually coloured, but those round the Moon are mostly white



What the halo or greasy ring looks like

WIND AND WATER AS SCULPTORS IN STONE

It is astonishing how wind and water can wear away the hardest rock, carving it into all sorts of fantastic shapes Of course, it takes thousands of years to do this, but how well the wind and water do their work can be seen from the striking examples of rock sculpture on this page On the left we see the Candelabra Rock on the Tonkin Lake, Indo-China, where the water through long ages has worn away the ground all round, leaving the rock standing on a narrow base like a vase or candelabra On the right is a striking case of wind erosion in the Death Valley, California, where are found many fantastic examples of natural sculpture of this kind

It may seem very wonderful that the wind can carve rocks like this and the one shown above. But of course the work is done by the constant blowing of sand against the surface, which has the effect of a powerful sand-blast. When some parts of the rock are softer than others they are of course worn away more rapidly, and so isolated pillars like this one in Arizona are the result

ROMANCE of BRITISH HISTORY

THE FIRST BOOK PRINTED IN ENGLAND

It was a great day when the first book was printed in England. There had been printing from movable types on the Continent for some years past, and William Caxton, who brought the art to England, had learnt it there. Caxton was a man of vision but it is safe to say that when he produced his first printed book in the Almonry at Westminster Abbey in 1474, he can have had no idea of the extent to which the art would have developed by the twentieth century. Here we read the story of the introduction of printing into England

It may seem a very astonishing fact that the first book ever printed in England should have been produced during the turmoil of the Wars of the Roses. Such, however, is the fact, for it was in 1477, while Edward IV was on the throne and in the period between the battle of Tewkesbury, at which the cause of Margaret and her son Edward Prince of Wales was lost for ever, and the battle of Bosworth, at which the last of the Yorkist kings was defeated and slain, that this book came into existence.

The printer was William Caxton, and his name should be for ever remembered with honour as that of the man who brought the greatest art the world has ever known to England.

In the old days, before the invention of printing, books could only be multiplied by the long and laborious process of being copied by hand. This method had many disadvantages. A book of any size took weeks and perhaps months to copy, and in the copying the scribe or clerk might make many slips. That is why the early manuscripts of the Bible vary a good deal in small and unimportant details.

Laborious Hand Copying

It must have been wearisome work copying out books, and we can easily forgive the scribes if they made a number of errors. When they were tired they would perhaps omit a line or they would misread another scribe's handwriting. The marvel is that they were able to do their work as well as they did. When a book is printed, whatever is set up in type is impressed on the paper, and so all the impressions from that particular set of type must be alike.

There being so few books, scholars and those who wanted to read suffered great inconvenience. Only thirty years before Caxton printed his first book we find in the statutes of St Mary's College, at Oxford, a rule that "no scholar shall occupy a book in the library above one hour, or two hours at most, lest others should be hindered from the use of the same."

When one of these books, written by hand, was bought, the affair was regarded as of so much importance that it was usual to assemble persons of consequence and character and to make a formal record that they were present on the great occasion, just as to-day we make a ceremony of the opening of a new church or college.

Another great disadvantage that resulted from books having to be multiplied by hand was that they were very expensive indeed. In ancient times Plato had to pay the equivalent of about £400 for three small books by another philosopher, and it is said that St Jerome nearly ruined himself by purchasing religious books. Yet his library would be considered very small indeed in these days.

Towards the end of the thirteenth century a Bible in nine volumes, written by hand, sold for 50 marks, or £33 6s. 8d. The money would be worth, of course, very much more to-day. At that period a labourer's wages were 1½d. a day, so that to buy a Bible a workman would have had to give the whole of his labour for nearly fifteen years!

Now we buy a book for a few shillings and think nothing of it, not realising what an enormous privilege is ours in being able to do what the greatest men before the middle of the fifteenth century were unable to do.

William Caxton, who brought printing to England, was born in Kent somewhere about 1422. We do not know much about his parents, except that they saw to it that he was educated, a wonderful privilege in that age of ignorance. Caxton himself recognised the boon that had been his, for in the prologue to one of his books he says, "I am bounden to pray for my father and mother's souls that in my youth sent me to school, by which, by the sufferance of God, I get my living, I hope truly."

William Caxton's device which was printed as a trade mark on his books. This photograph is given by courtesy of the John Rylands Library, Manchester

Caxton's Apprenticeship

At fifteen or sixteen he was apprenticed to a mercer of London, one Robert Large, who afterwards became Lord Mayor, and when the apprenticeship was finished Caxton became a freeman of the Mercers' Company and a citizen of London. Later on he was made a liveryman of the Company, and had an important say in its government. "Mercer" was the old fashioned name for a dealer in silks and other fabrics, and it was quite a common practice for well-to-do parents to apprentice their sons to London mercers, as it was regarded as a sure road to wealth and influence.

Caxton was evidently an industrious boy and pleased his master, for when Robert Large died the boy had not finished his apprenticeship, but Large left him a sum of twenty marks so that he could finish his term.

Apparently the youth finished his apprenticeship in Bruges, to which place he had been sent. In that city there lived a body of English mercers, and at the close of the apprenticeship young Caxton set up in business for himself at Bruges, and altogether he remained there for thirty years.

He must have prospered, for in the year 1450 we find that he became

surety for another English merchant for a sum of £100 a considerable amount for those days

He must also have been very highly thought of by his fellow countrymen for when Edward IV granted the Merchant Adventurers as they were called a new charter for the government of English merchants in the Low Countries most of whom were mercers Caxton was appointed to the office of Governor It was a responsible post for the Governor with a small body of fellow merchants to help him settled all disputes that arose amongst the English merchants in the Low Countries and regulated imports and exports of merchandise

A Great Lover of Books

He was also the spokesman for the community to the English Government and it was only natural that when a commercial treaty between England and the Low Countries was about to run out, Caxton, with one other, was commissioned by the English Government to seek a renewal of the treaty The plan was not successful at the time but when two or three years later the Duke of Burgundy who ruled the Low Countries died and another Duke Charles the Bold succeeded him things improved for Charles was married to Margaret sister of Edward IV Caxton opened negotiations and was soon able to renew the old commercial treaty between the two countries

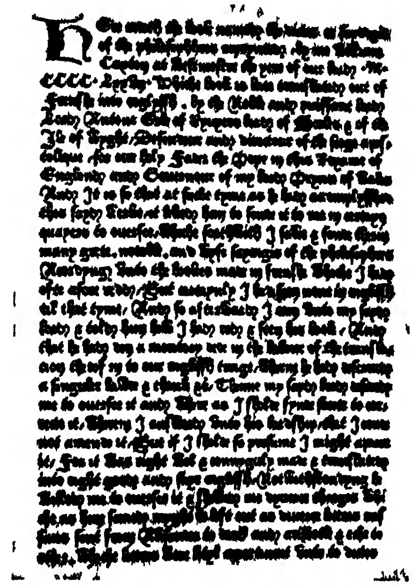
We may be thankful that Caxton ever went to Bruges for it was during his stay on the Continent that he became interested in the art of printing Of course, sooner or later printing would have come to England but were it not for William Caxton it might have been very much later, to the great loss of English literature and education

Caxton was a great lover of books and reading and this need not surprise us for there have been many English manufacturers and merchants who have done great things for learning

Caxton's life while on the Continent must have been a very busy one He had his own business to attend to and all his public work in connection with the Merchant Adventurers' Association Nevertheless he found time for travel and for reading

He had already acquired a proficient knowledge of the French and Dutch languages and he began to translate in to English a French romance on the history of Troy This was called The Recuyell of the Historyes of Troye" The word recuyell ' is an old French word meaning collection '

The English Duchess of Burgundy showed great favour to Caxton and soon after her marriage Caxton gave up his commercial work altogether and entered her service No doubt he had already made a fortune and the court appointment enabled him to spend much more time in his literary pursuits He was able to complete his translation of the history of Troy and at once there seems to have been a great demand for the book



A reduced facsimile of a page of Caxton s 'Dictes and Sayings of the Philosophers, the first book to be printed in England

It was this demand that induced Caxton to make up his mind to learn the art of printing He wanted to multiply the book much more rapidly than could be done by hand copying

No one can say exactly when printing from inked blocks was first invented There is a Chinese book so printed dating back to the time of Alfred the Great, but it was not till the middle of the fifteenth century that printing began in Europe It is generally recognised that we owe the idea of printing from movable types to Johann Gutenberg of Mainz who, however was associated with another man Johann Fust who lent him money to experiment and begin his work

When Caxton made up his mind to learn the art of printing there were already a number of printing presses in different cities of Europe and many fine books had already been printed

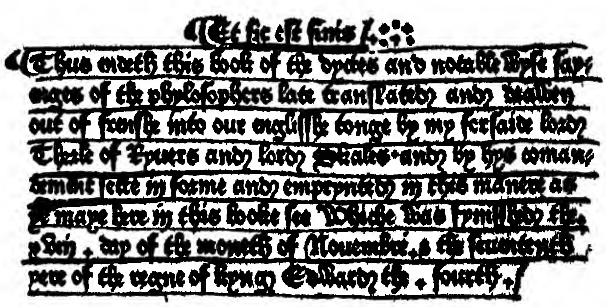
We have no knowledge as to where Caxton studied the noble art, nor do we know where his first book was printed He tells us himself that he finished the translation of the history of Troy in Cologne so it may have been there that he studied printing On the other hand there was a famous printer in Bruges named Mansion, and some think that Caxton had lent him money to carry on his enterprise What we do know, however is that probably in 1474 the Recuyell was produced, the very first book to be printed in the English language

Caxton's Press at Westminster

It is the busy people of the world who always find time to do extra work and Caxton tells us that he began his translation of the history of Troy as a preventive against idleness Having produced one book he gave himself no rest, and in the same year completed another translation into English, The Game and Playe of Chesse" It was from a French translation of a Latin book, and it was printed at once probably at Bruges

But Caxton was not content to go on printing English books in a foreign country He made up his mind that such a valuable art as printing should be brought to England and that English books should be printed at home

He therefore returned to England in 1476 and set up a printing press at Westminster in some part of the Abbey Exactly where it was we are not quite sure but it is believed to have been in the Almonry We know it was within the Abbey precincts for Caxton himself in some of his books tells us that these were printed in Westminster Abbey and in an advertisement which he issued he announces books for sale and bids the customer come to Westminster in to the almonerye at the reed pale" 'Reed pale" or Red Pole" sounds rather like the name of a public house but we must remember that in those days every tradesman had a sign and a name for his place of business



Et sic est finis.
Thus endeth this book of the dyctes and notable wyse sayenges of the phylosophers late translated and drawen out of frenshe into our englisshe tonge by my ferfaide lord Therle of Ryuers and lord Skales and by hys comandement sette in forme and emprynted in this maner as ye maye here in this booke see Whiche was fynisshed the xviij day of the monethe of Novembre & the seuenteenth yere of the regne of kyng Edward the fourth.

The colophon or tail-piece of Caxton's first book printed in England It gives information now placed on the title-page This and the facsimile above are given by courtesy of the John Rylands Library, Manchester

Why did Caxton begin printing in Westminster Abbey? No one can say Some people think that the Abbot of Westminster was a friend and patron of his, but we find no Caxton books dedicated to the Abbot Others think that he did his work in the Abbey for safety's sake Those were dangerous days to live in, and anything new was regarded with suspicion Printing could easily have been regarded as magic, and anyone who was thought to be dealing in magic or doing anything which opposed the church

might easily be burnt to death as a wizard or a heretic. Such suspicions would be allayed when the work was actually carried out within the precincts of a notable church with the permission of the ecclesiastical authorities.

Whether or not this was the reason Caxton printed his books in Westminster Abbey, the scene of the first printing office has left its mark on the industry ever since. The place where other goods are manufactured is called a "factory," but the place where printing is done is still called a "chapel," and the body of workmen who produce the printing in a particular place is also known as the chapel. This is a relic of the early days when printing was done actually in a chapel building.

The first book to be printed in England was a work translated from the French by Earl Rivers, the brother of Edward IV's queen, Elizabeth Woodville, and revised by Caxton. It was called the "Dictes and Sayings of the Philosophers," and was published on November 18th, 1477, a very notable day in the history of England.

Caxton went on producing many books. Copies of some of these exist to-day, and we may see them in the British Museum in London and in the John Rylands Library in Manchester; but in addition to those of which we have copies he printed many others. We know them only by fragments which have been found in the bindings of other books.

Caxton had men to help him with his printing, but he did a great deal of the work himself, and he was very industrious. Most of the books he printed were translations of foreign works, and in most cases he carried out the translations himself. Where he did not he edited the manuscript before printing, so that he was not only a printer, but an editor and translator as well. He also wrote prefaces or prologues to the books, so we may also with truth and fairness describe him as an author.

He loved romances, and gave his countrymen many of these, including "The Noble Histories of King Arthur and of Certain of his Knights," by Sir Thomas Mallory; "The History of Reynard the Fox," "The History of Godfrey of Boulogne," and "The Life of Charles the Great." He translated and printed the fables of Aesop, and he first gave to the English people in print the works of the father of English poetry, Geoffrey Chaucer.

Even the great classical masterpieces of the Ancients were not omitted, and he translated Virgil's Aeneid into English and printed it on his press. How he came to do this he tells us in a good deal of detail as set forth in the following words:

"After divers works made, translated and achieved, having no work in hand, I, sitting in my study, where, as lay many divers pamphlets and books, it happened that to my hand came a little book in French, which lately was translated out of Latin by some noble clerk of France, which book is named 'Aeneid,' as made in Latin by that noble person and great clerk, Virgil, which book I saw over, and read therein . . . In which book I had great pleasure, because of the fair and honest terms and words in French, which I never saw before like, nor none so pleasant, nor so well ordered, which book, as me seemed, should be much requisite to noble men to see, as well for the eloquence as histories.

"And when I had advised me in this said book, I deliberated, and concluded to translate it into English; and forthwith took a pen and ink and wrote a leaf or twain, which I oversaw again to correct it; and when I saw the fair and strange terms therein, I doubted that it should not please some gentlemen which late blamed me, saying that in my former translations I had over curious terms, which could not be understood of common people, and desired me to use old and homely terms in my translations; and fain would I satisfy every man, and so to do, took an old book and read therein, and certainly the English was so rude and broad, that I could not well understand it; and also, my lord abbot of Westminster did show to me late certain evidences, written in old English, for to reduce it into our English now used; and certainly it was written in such wise, that was more like to Dutch than to English. I could not reduce, nor bring it to be understood. Certainly the language now used varieth far from that which was used and spoken when I was born."

It was no easy task to translate books into English in those days, for English was written and spelt by everyone as he liked. There was no proper and regular way of spelling words as there is to-day. We may be thankful that Caxton was so industrious, and that he spared no pains to do his work well.

Caxton received favour from Edward IV, from Richard III, and from Henry VII, and there is an old picture in a manuscript in Lambeth Palace which shows Earl Rivers presenting Caxton to Edward IV, who is receiving a copy of the first printed English book.

We might ask why Caxton never printed the Bible, the greatest of all books found in English, but of course at that time people were not allowed to have the Bible. John Wycliffe had translated it, but possession of a copy might easily have led to the stake.

Altogether Caxton printed over a hundred books, many of them large volumes. It used to be thought that the very first thing he printed in England was the "Dictes and Sayings of the Philosophers," but in the year 1928 there was found in the Record Office in London a sheet known as an Indulgence, printed by Caxton at Westminster and issued by the Abbot Sant in 1476.

This great man, to whom we owe so much, died in 1491, just before he was seventy years old, and he was buried in the church of St. Margaret's, Westminster, where there is a tablet and a stained glass window to his memory, both erected in the nineteenth century. He was a worker to the end, and on the day on which he died he was translating "The Lives of the Fathers" from a Latin work.

Of course, printing has not been an absolutely unmixed blessing, as Caxton and the other early printers thought it would be. Many bad books have been multiplied by printing, but the balance is overwhelmingly on the side of good. How could we doubt this when we remember that it is by means of the printing press that the Bible has been given to the whole world.

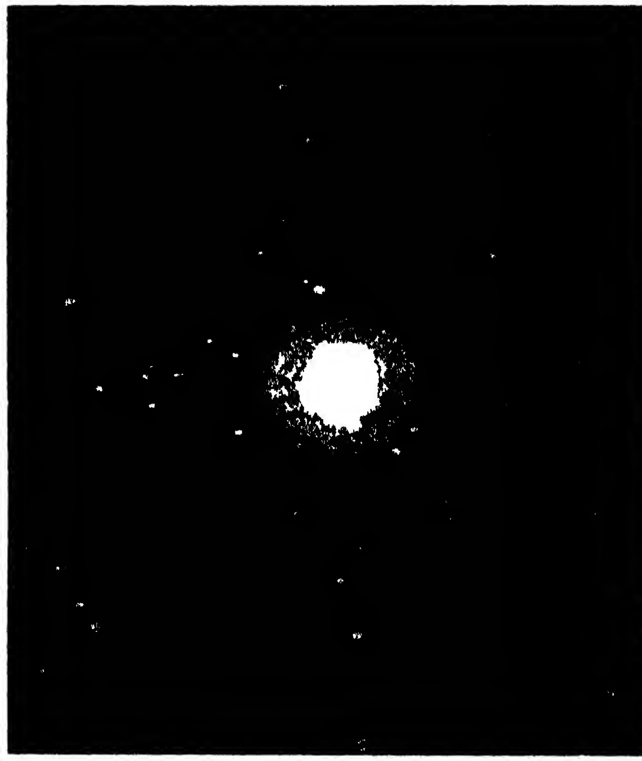
We remember Tennyson's "Epitaph on Caxton":

> Thy prayer was Light—more Light—while Time shall last!
> Thou sawest a glory growing on the night,
> But not the shadows which that light would cast,
> Till shadows vanish in the Light of Light

We honour Caxton as one of the very greatest of Englishmen.

Caxton reading the first proof-sheet from his printing press set up in the Almonry at Westminster Abbey in 1474. From the painting by E. H. Wenhert

GIGANTIC STAR CITIES IN DISTANT SPACE



On this page are given three remarkable photographs of spiral nebulae which Sir James Jeans calls Star Cities The photographs were taken at Mount Wilson Observatory, and the one on the left shows the spiral nebula in the constellation Canes Venatici, which is calculated to be 1 100,000 light-years away That on the right is a nebula in Pegasus, which we see at a different angle from the nebula in the bottom picture These nebulae are, as is now known, distinct universes with countless numbers of stars either formed or forming

This nebula which is seen in the constellation of the Great Bear is a magnificent example of a spiral nebula and was the first that was seen to be rotating Its light takes 1,600,000 years to reach us Yet as nebulae go it is comparatively near These nebulae probably start as enormous masses of gas, and if they had no movement would assume a spherical form gradually contracting under the influence of gravitation But in some way they have acquired a rotary movement, and the result has been to flatten them out, just as the Earth is flattened towards the poles owing to its rotation Gravitation draws their particles closer and closer together, and with the contraction the rotation becomes faster That makes them flatter still The attraction of other great masses in space has caused the gas of the nebulae to be drawn out, and then, as the result of gravitation, has produced stars from the gas In photographs of some of the distant nebulae we can detect the stars Eventually a spiral nebula becomes the parent of a stellar universe. Such is the belief of astronomers

WONDERS OF THE SKY

THE FIXED STARS THAT ARE NOT FIXED

Astronomers studying the stars by means of delicate instruments find that they appear to move in small ellipses in the heavens. They do not really move in this way, but the appearance is due to a fact which is known as the aberration of light, and which was discovered by an English astronomer in 1727. The matter is explained here by means of simple and familiar illustrations

We often speak of the fixed stars, but, of course, there are no such things in the Universe as "fixed" stars. All the stars are moving through space at very rapid rates, and the distances they travel amount in the course of a year to hundreds of millions of miles.

We talk of fixed stars, however, for convenience to distinguish them from the planets, whose movements in the heavens are obvious, even to the naked eye. The word planet means "wanderer," and the name was given to the members of the Sun's family because these bodies, Mercury, Venus, Mars, Jupiter and Saturn, were noticed by the people of ancient times to wander in the sky among the other stars, which appeared fixed.

We Live on a Wobbling Earth

But while it is perfectly true that to the rough observation of the naked eye the stars seem fixed, when they are carefully examined by means of instruments they are found to have apparent movements. These movements, however, are only apparent, and are due to causes which may be explained.

In the first place the Earth's north pole, which points almost directly to the Pole Star in the sky, does not remain always in this position relative to the Pole Star. As a matter of fact, the Earth as it spins round on its axis is wobbling, just as a peg-top, while rotating on its peg, wobbles during a revolution. This movement of the pole is due to the fact that the Earth is not a perfect sphere, so that the attraction of the Sun and Moon affect it in this way. The matter is explained elsewhere in this book, and men of science speak of the changes in the position of the Earth's pole and axis as precession and nutation.

Straying from the Recognised Path

Now this movement of the north pole, which is very considerable over the course of thousands of years, affects the positions of the stars when they are carefully observed and the positions measured by delicate instruments.

But there is another cause for the apparent movement of the stars, and it is known by the rather formidable name of the aberration of light. As a matter of fact, aberration is only another word for wandering, and the aberration of light merely means the straying of light from its recognised path. This straying of light, or aberration, as men of science prefer to call it, leads to a displacement of the true position of a heavenly body as seen by an observer on the Earth, and makes a star appear to change its position.

This may seem rather difficult and complicated, but it can be made quite easy to understand by looking at the rain when it is falling heavily on a calm day, with little or no wind. If we stand still, as the man in the first picture is doing, we shall see the raindrops falling perpendicularly from the clouds to the ground.

But it is never very pleasant to stand in the rain, and so we decide to walk quickly to a place of shelter as the girl is doing in the second picture. As we look at the rain it now seems to be falling slantingly towards us and we get much wetter in front than behind. If we happen to ride through the rain on a bicycle, travelling much faster than if we are walking, then the raindrops seem to be falling still more slantingly towards us as shown in the third picture on this page.

Watching the Rain from the Train

We can carry our illustration still farther, for if we happen to be travelling in an express train when the rain is falling heavily on a calm day, the raindrops, as we look at them out of the window of the railway carriage, appear to be speeding past almost horizontally. Yet when the train comes to a standstill we see, perhaps to our surprise, that they are really falling perpendicularly from the clouds to the Earth.

Now what makes these vertically falling drops of rain appear to be descending at an angle when we look at them as we walk or ride? Well, the slanting appearance of the falling rain is due to two facts; first, that the drops take some time in their descent, and

The falling raindrops teach us an important fact about light. If we stand still in the rain on a calm day the drops are seen to fall perpendicularly, but if we walk through the rain they appear to fall slantingly, and the faster we move the more slantingly do the drops seem to come. The same thing happens with light from the stars as it reaches the Earth travelling in its orbit round the Sun

second that we ourselves are moving The slanting appearance of the rainfall as we move through it is called aberration

What is true of the rain and ourselves is equally true of light from distant stars and other heavenly bodies, and the moving Earth If our planet were stationary and light moved at infinite speed, that is if it reached us without any interval of time for its journey we should see the stars exactly where they are

But the Earth is moving round the Sun changing its position every moment, and the light from the stars takes years and sometimes centuries to reach us The result is the aberration of light

The Lesson of the Rain

Just as the raindrops when we move towards them seem to be falling slantingly so the light from the stars as the Earth moves in its orbit seems to be coming slantingly towards us and this causes a star to appear not where it actually is but where the light seems to be coming from Try the experiment of standing in the rain when it is falling vertically downwards on a calm day and then run through it and the matter will be quite clear to you

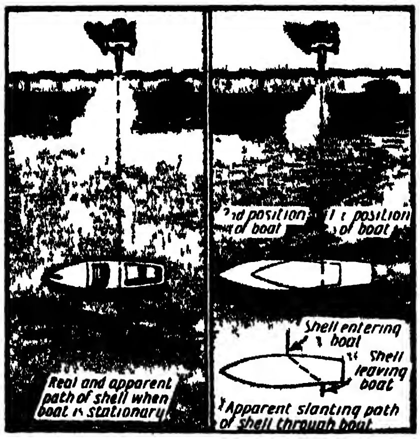
With regard to the actual movement of the stars in space this was discovered by Edmund Halley the great Astronomer Royal after whom Halley's Comet is named He was also the first man to make a trustworthy catalogue of the stars in the Southern Hemisphere a work that had been done for the Northern Hemisphere by John Flamsteed the first Astronomer Royal of England

It was in 1718 that Halley discovered that the stars Arcturus and Sirius had changed their places in the heavens since the days of the Egyptian astronomer Ptolemy who lived in the second century of the Christian Era They had moved southward Arcturus by a full degree and Sirius by about half a degree Even when observed with the naked eye these two stars were no longer in the positions allotted to them by Ptolemy

Since Halley's day a great deal of time and care has been given by astronomers to the important matter of star movements and it is now known that the stars are all in motion

But it was not until the year 1904 that the nature of the star movements was seriously considered It was not known whether the movements were apparently haphazard or whether the stars as a whole moved in definite directions

As a matter of fact, it had been assumed that the movements were haphazard and according to Dr W M Smart of Cambridge University Observatory it was supposed that "the universe of stars was a kind of chaos in which no law or order had been detected The picture of the stellar universe in the minds of astronomers before 1904" continues Dr Smart, "resembled in many ways the picture one would have from a stationary



Here is a good illustration of aberration If the boat is stationary the shell from the gun goes straight through it, but if the boat is moving forward the shell seems to take a slanting path as it passes through

balloon of a crowd of people walking aimlessly about within a great open park at all speeds say up to four miles an hour People would be observed walking about haphazardly in all directions and if the observer in the balloon were provided with adequate facilities for counting the number of people proceeding in a particular direction he would find that this number would be practically constant whatever the direction considered"

But since that time a great deal has been discovered about the movements of the stars, and we now know that there are two definite streams or swarms of stars drifting in two distinct directions relatively to the Sun Each of the streams is directed towards a definite point, and the two swarms of stars are intermingled

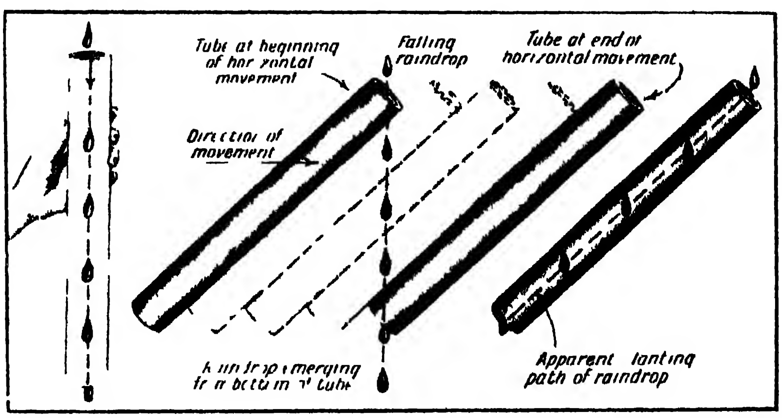
It is as though we were looking down from, say, the Monument in London or any other tall building upon the streets below and saw the people walking Although there would be some crossing from one side of the road to the other at various angles the general impression would be of two great streams of people one walking up the street and the other walking down The two streams would be intermingled but we should, as we looked down, see the general drift of both

Two Streams of Stars

This is a very good illustration of the two star streams in the heavens While the direction of each can be generally detected there are of course many stars which while following the general direction, are like the people crossing the road at an angle

The star movements are well described as a 'drift' The stars are not like a regiment of soldiers marching definitely in parallel lines The two streams of stars are not equal One seems to contain about half as many stars as the other

This streaming of the stars in two main directions is a very puzzling phenomenon for astronomers who with their present knowledge cannot explain it, but the matter is still being studied at observatories in all parts of the world and as time goes on undoubtedly our knowledge will increase



If we stand still holding a tube upright on a calm rainy day the drops fall through the tube without touching the sides If, however, we walk forward we must slant the tube if the drops are to go through without touching the inside This picture showing successive positions of the slanting tube and a falling drop of rain makes the matter clear The apparent slanting fall of the raindrop through the tube is a case of aberration

Of course, the stars in the two streams are not moving at a uniform rate In addition to this general drift in the heavens there seems to be no doubt that in the course of every century the stars have really changed their places with reference to each other These individual motions of bright stars seem to be on an average greater than those of the faint stars, but that is probably only because the bright stars are so much nearer to us

Of course astronomers now have an enormous advantage in checking star motions by comparing photographs, and this advantage will increase as time goes on In the old days the only way of carrying out these researches was by comparing star catalogues and errors were sometimes made

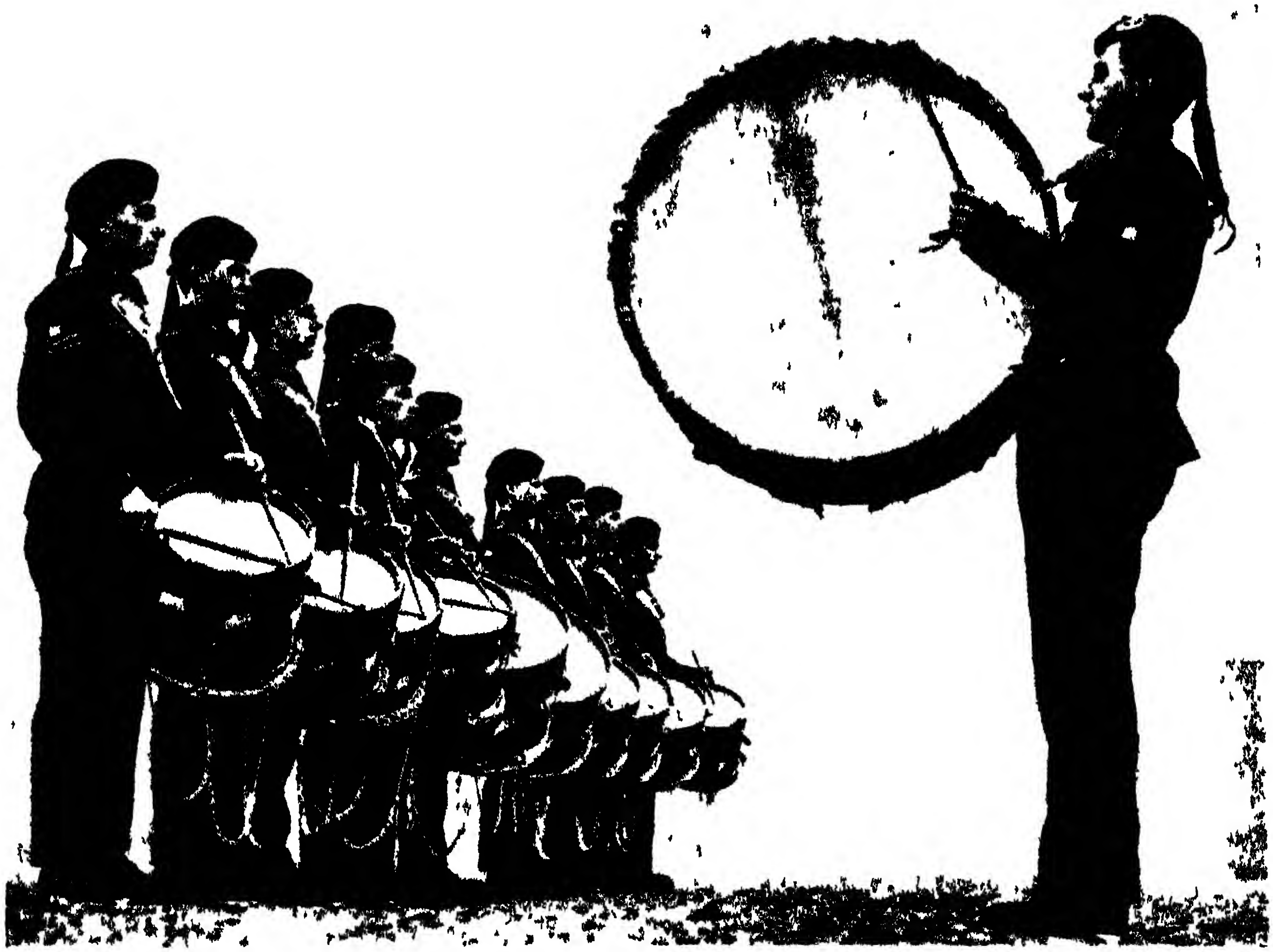
WHY A DRUM MAKES A NOISE LIKE THUNDER

The drum is a very ancient instrument, and is found even among savage people, yet it has its part in an orchestra producing the most refined music in a civilised land. It is one of the instruments of percussion, that is an instrument whose sound is obtained by striking. Here we read many interesting facts about the different kinds of drums and the sounds they produce

WHY does a drum make so much noise when the tightened skin is beaten with the drumstick? The reason is that the stretched skin when struck is set vibrating, and this communicates its vibrations to the air inside the drum. These vibrations are carried to the skin on the other side of the drum, and that also is set vibrating and in turn causes vibrations in the air. In this way the beating of the drumhead keeps up a constant succession of waves giving a booming sound like that of the sound waves which cause thunder.

The rattling noise in the type of drum known as a side drum is caused by a number of cords of catgut which are stretched across the lower end of the drum. They are called snares, and when the beating of the upper skin sets the lower skin vibrating this strikes rapidly again and again against the catgut cords causing the rattling sound. To obtain the rolling, thunderous effect two blows are struck with the left hand and two with the right hand very regularly and rapidly, so as to produce a continuous tremolo. This is very difficult to do and only those who have started learning when very young are able to do it well. That is why drummer boys are trained in their early years.

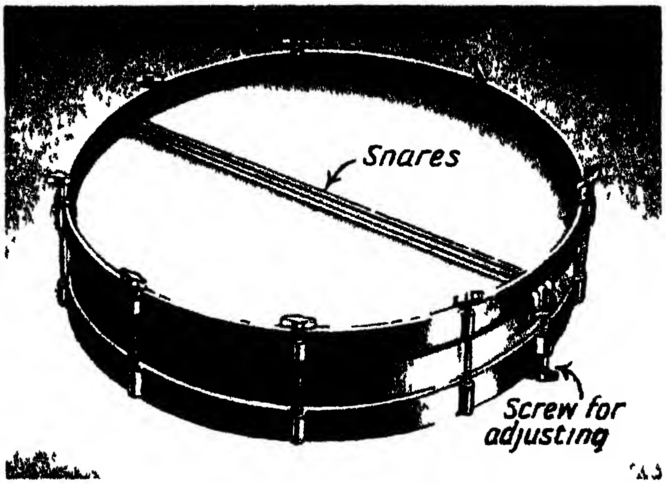
The drum is a very ancient instrument found all over the world and it is said to have been brought to Europe from the East by the Crusaders. There are three kinds of drum. First of all there is the side drum already referred to, which consists of a cylinder of wood or metal with a calfskin stretched over both ends. The skins are kept firm by wooden hoops, the skin being lapped round a small hoop and then kept down by a larger hoop placed over it. The two large hoops at the top and bottom of the drum are connected by an endless cord which passes zig-zag fashion from hoop to hoop, and can be tightened or loosened by



Drummers of the Gordon Highlanders with their big bass drum and the smaller side drums of various sizes

means of leather braces The depth of the cylinder varies and this type of drum is struck in the centre of the skin by two sticks of hard wood with elongated knobs

Then there is the bass drum often called the big drum which is beaten with a stick ending in a soft round knob In this case the skin is struck in the centre and it is kept tightened by cords and braces or by rods and screws In neither of these drums is the tone definite enough to be tuned A more musical type of drum is the kettledrum in which a head of vellum is laid over an iron ring fitting closely over a metal kettle or shell more or less in the shape of a hemisphere The skin is tightened or loosened by screws fitted to the ring and can be tuned in this way Two kettledrums are found in cavalry bands one being carried on each side of the horse in front of the drummer and orchestras usually have two, though sometimes there are more



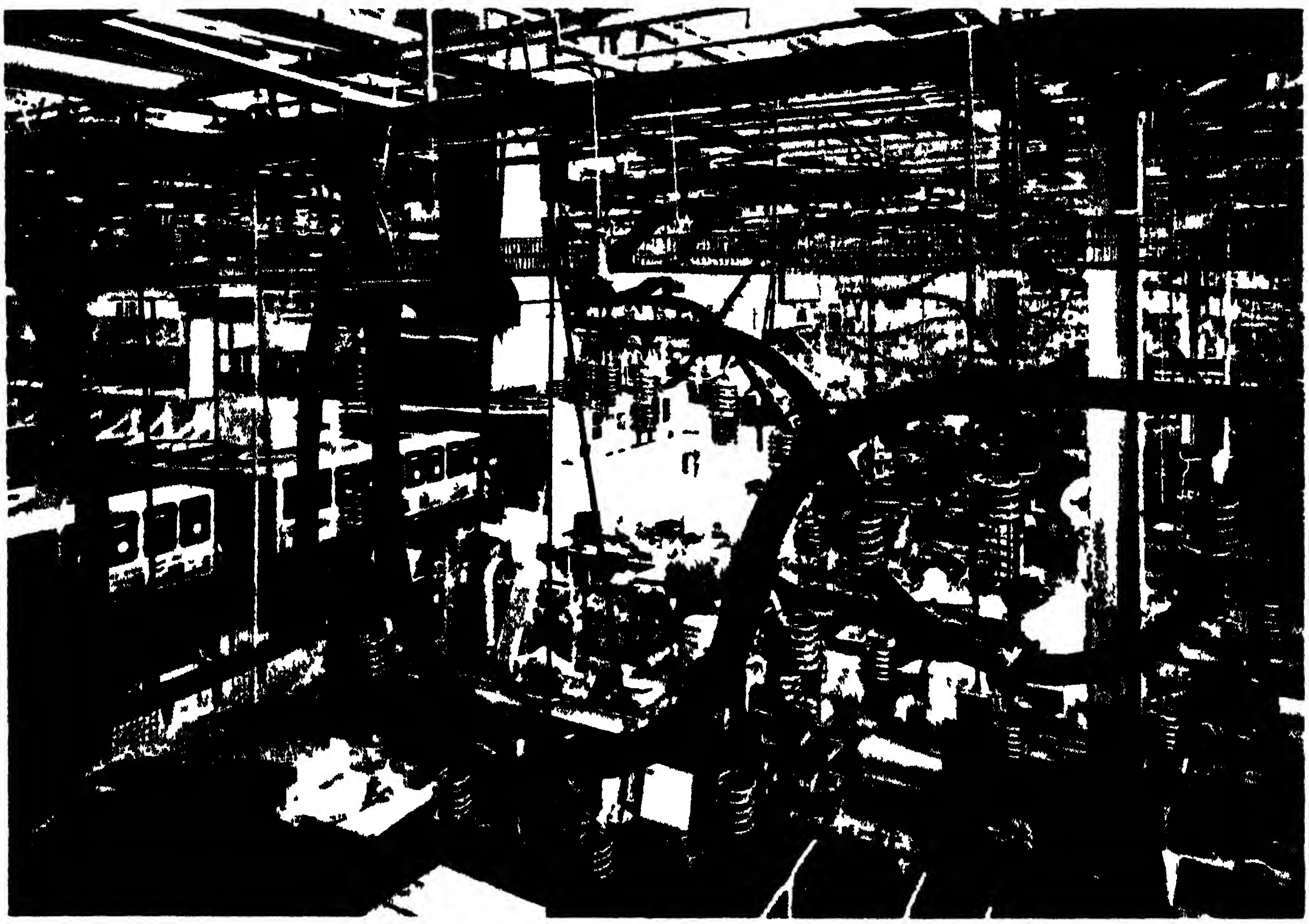
The under side of a small drum showing the snares and the screw for tightening or loosening them

Beethoven was the first composer who recognised the musical possibilities of the kettledrum Berlioz in his Requiem makes use of eight pairs of kettledrums

A kettledrum is struck at about a quarter of its diameter and the best kind of stick is whalebone with a small wooden button covered with a thin piece of fine sponge A less successful stick has a knob of felt and others have rubber discs or knobs of cork covered with leather These however are not very satisfactory

Of course the tambourine which is a frame with a single skin stretched over the top, and with the bottom open, is really a primitive form of drum Indeed it is probably the very earliest form

MECHANICAL HANDS THAT LIFT AND CARRY



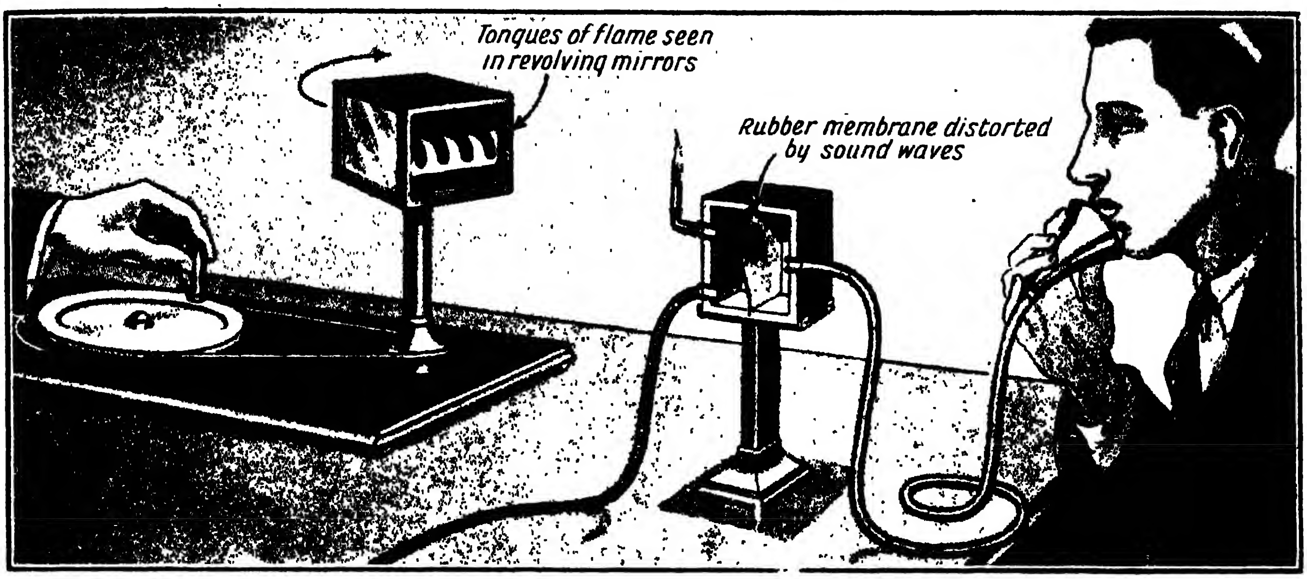
Lifting things up by hand and putting them down again wastes more time and costs more money in wages than anything else in industry If workers have to carry articles during manufacture from one department to another, the cost of handling may be more than the actual cost of the raw material and the manufacturing processes To reduce handling costs and to save time, engineers have designed ingenious equipment such as the conveyor system shown above working in a motor vehicle factory This type of conveyor not only moves parts from bench to bench and from machine tool to machine tool on one floor level, but it carries the articles from one floor to another and around corners to deliver them to the workmen's benches

THE FLAME THAT DANCES WHEN WE SING

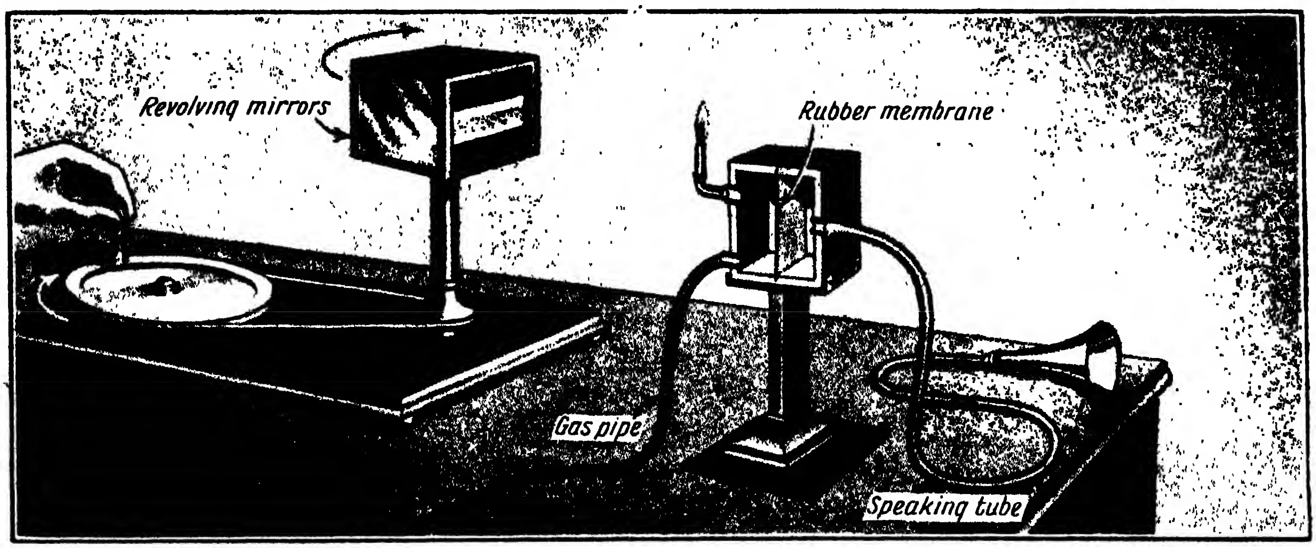
We cannot see sound, for sound is the sensation produced through the ear by vibrations in the atmosphere. A bell is sounded, and the clapper striking the bow of the bell causes the metal to vibrate. The vibrations set up waves in the air, and these, when they strike our ear-drums, pass a message on to our brain. There would be no sound without the vibrations in the air, but even with a set of revolving mirrors In other words, we give optical expression to the vibrations that set up sound.

The device for doing this is known as a flame manometer, and it was invented by a musician named Koenig.

It consists of a box divided into two chambers by an elastic partition made of rubber or goldbeater's skin; leading into one chamber is a tube with a mouthpiece at the end, and leading into one of the mirrors. Then we rotate the box, and the flame appears as a continuous band of light. Now we take up the mouthpiece of the other tube and sing into it the vowel E on the note C. At once the band of light is divided up into a series of tongues. When we sing the vowel O on the same note the arrangement of the tongues varies, and so according to the note sung or the sound made the flames



These pictures show how the human voice will make a flame dance. The man is singing into a tube, and the sound waves move a rubber diaphragm in a small chamber. Gas enters the chamber on the other side of the diaphragm and passes to a flame. Opposite the flame is a cubical box with mirrors on its upright sides. When this box is rotated the jerking of the flame caused by the vibrating diaphragm is indicated by the reflection in the mirrors appearing as tongues of flame, and the form of the tongues vary according to the singing



When the mouthpiece is not sung into and the rubber membrane remains still, the flame burns steadily and the reflection in the revolving mirrors appears as a continuous line of light, very different from the tongues of flame which are seen in the upper picture

the vibrations there would be no sound unless there were some person to hear it.

But while in the strictly scientific sense it is perfectly true that we cannot see sound there is another sense in which we may almost be said to see it. Of course, what we really see is the effect of sound, the waves or vibrations in the air or other gas being indicated by the variations in a flame of gas reflected in into the other chamber there is a pipe through which gas can pass

Out of this chamber there is a second small tube with a gas jet at the end. Opposite this box is another cubical box with each of the four upright sides covered by a mirror. A simple mechanism enables this mirror box to be rotated rapidly.

We light the gas jet and it shines vary, and thus it may be said that in a sense we can see the sounds that are made in the mouthpiece.

The device is called Koenig's Apparatus, and the flames are called by scientists manometric flames, because they are due to the elastic force of the gas in the chamber. Manometric is made up from two Greek words meaning to measure something that is not dense.

SIMPLE EXPERIMENTS THAT ALL CAN DO

There are plenty of experiments that one can carry out at home with no more elaborate apparatus than a test-tube or two and such things as jam jars, saucers, tumblers and other familiar vessels found in every house.

First of all let us perform an experiment which sounds very surprising and that is to boil water in a test-tube in which a piece of ice remains in

Ice remains frozen in a tube where water is boiling

the frozen state We nearly fill the test-tube with cold water and then sink in it a small piece of ice by attaching to this a nail or piece of lead

It is necessary, if the experiment is to be carried out satisfactorily, that the ice should remain at the bottom of the test-tube. Now with a holder like that shown in the picture or one made out of a piece of wire twisted round the tube, we hold the upper part of the tube in the flame of a methylated spirit lamp or bunsen burner.

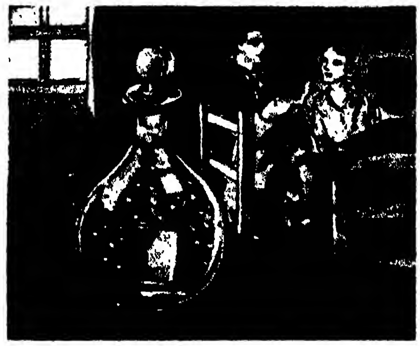
Before very long the water in the upper part of the test-tube will begin to boil, but the ice at the bottom does not melt. Why is this? The reason is that water is such a bad conductor of heat that the heat of the boiling water is not transmitted to the water at the

Mixing sand with water and filtering it through blotting-paper

bottom of the tube for a long time and so the ice remains frozen

Now let us make a filter out of a piece of ordinary white blotting-paper and then carry out one or two simple experiments to see what filtering will and will not do We fold a square piece of blotting-paper across twice and then insert it point downwards in an ordinary tin or aluminium funnel, opening it out so that any liquid poured into the funnel must pass through the blotting-paper.

Mix some fine silver sand with water in a tumbler. When it is well mixed, pour through the blotting-paper filter. The water will pass through, but the sand will remain behind, caught by the blotting-paper. Mix soot or fine coal dust with water and do the same thing again. The water passes, but the dust is held by the filter. These experiments show what filtering will do; it will separate solid substances from the liquid in which they are suspended



Dewdrops forming on a bottle of very cold water

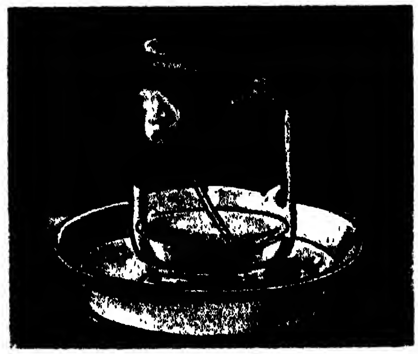
We will now see what filtering will not do. Dissolve some sugar or soda in water and pour the solution into the funnel The liquid passes through and neither sugar nor soda is held back, for these substances are in solution. Filtering will not change the character of a solution, for the dissolved solids pass through the filter with the liquid.

Hoar-frost forming on a bottle containing a freezing mixture of snow and salt

Dissolve a little blue from the blue-bag in the water and pour through the filter. The colour passes through because it is dissolved matter.

Here are two interesting experiments we can carry out with an ordinary water bottle from a bedroom or a glass jug We fill it with very cold water from the tap and then carry it into a warm room in which several people are breathing. At once the outside of the bottle becomes covered with dewdrops. The water vapour in the air has become condensed into moisture by the cold glass. This is how dewdrops are formed in the garden or field; as we see on page 339.

If, instead of filling the glass bottle with cold water, we fill it with a freezing mixture such as snow and salt,



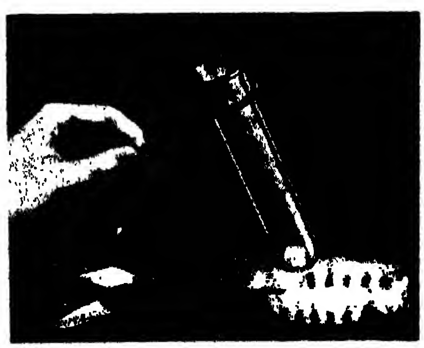
Proving that rust takes oxygen gas from the air

the moisture deposited on the glass will be frozen and appear as hoar-frost.

Here is an experiment to prove that rust takes oxygen from the air. Place some iron filings in a piece of muslin and after moistening, tie these to a glass rod or tube and place inside an inverted glass jar standing in a bowl of water, so that the water just covers the edge of the jar.

A week later the water will have risen in the jar because oxygen from the air inside the jar will have combined with the iron to form rust which is oxide of iron and the water will have risen to fill the vacant place. If we now hold the jar upside down and place a lighted taper inside, the flame will go out, as there is not enough oxygen to support combustion

One other experiment we may carry



Vaporising a substance by heat and allowing it to condense again

out. Place a piece of camphor in a test-tube and heat gently over a flame. The camphor will disappear gradually, being turned into vapour, but it will condense again at the top of the tube. The same thing can be done with sal-ammoniac

MARVELS of MACHINERY

THE VALUE OF THE ELECTRO-MAGNET

The invention of the electro-magnet, in which many famous scientists had a part, but which was really developed by the genius of Michael Faraday, has been an untold boon in the heavy metal industries, where it can lift, move, and load or unload great masses of iron and steel in a tithe of the time that would be needed with other apparatus. In these pages we read something about the electro-magnet and its work

THE use of the magnet for practical purposes is a discovery or invention of comparatively recent times. Of course, the lodestone was known to the Ancients, and the Chinese claim to have used magnetic needles on their land journeys long before the compass was known in Europe.

Except in the form of the mariner's compass, the ordinary magnet is of no very great practical service to man. It is when a rod or horseshoe of iron is alternately made a magnet and then deprived of its magnetic power that it becomes of real use, and this form of magnet can only be produced by means of electricity.

We wind an iron or steel rod or horseshoe round with wire, and then pass an electric current through the wire, when the metal inside becomes a magnet. If this metal be steel, then when the current is cut off the metal still remains a magnet, but if the rod or horseshoe be made of soft iron, well annealed, then directly the current is turned off the metal ceases to be a magnet.

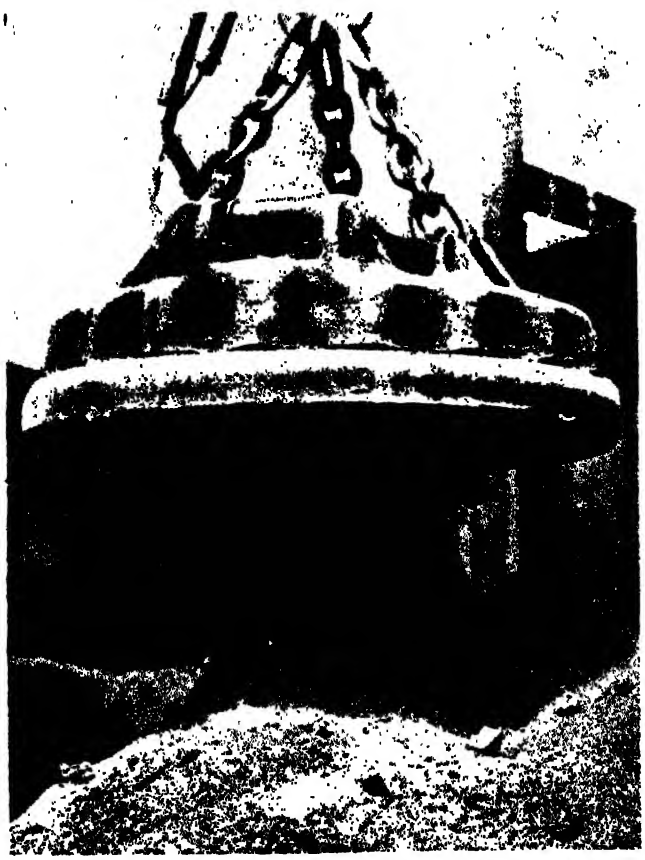
Even the person least instructed in the details of magnetism and electricity will realise the great importance of this. All our modern electrical machinery depends upon the principle, and we get it even in such a familiar domestic appliance as the electric bell.

If we turn to the picture on Page 120 we shall see that the success of the bell depends on the soft iron horseshoe of the electro-magnet being made alternately a magnet and an ordinary unmagnetised piece of iron. In this way it alternately attracts and releases the armature, and rings the bell.

It was Hans Christian Oersted, a professor in Copenhagen University, who discovered electro-magnetism in 1819 by noticing that an electric current acted on a magnetic needle.

For a long time it had been suspected that there was some connection between magnetism and electricity, but no one had proved it as a fact. This discovery was the beginning of the great science of electro-magnetism, and many great men, one after the other, have contributed something which has brought it to its present high state of efficiency.

But none of these was greater than the brilliant English scientist Michael Faraday. He was really the father of electro-magnetism, and as time goes on we realise more and more what the world owes to that great but most modest man.



Here are two remarkable examples of huge electro-magnets being used for the handling of great masses of metal. On the left we see a magnet sorting out from dust and other rubbish and lifting up for removal iron filings from a great heap where they have been dumped. On the right a magnet is loading pig iron into a railway truck. Many tons of metal are raised at each lift

In the year following Oersted's discovery another scientist François Arago a Frenchman performed an interesting experiment He plunged into a mass of iron filings a copper wire which he connected with the two poles of an electric battery When he lifted out the wire with the current still passing through it he found that its whole surface was covered with iron filings arranged transversely As soon however as he cut off the current the iron particles at once fell off the wire

The thought came to Arago that the current had made the iron filings magnets temporarily It was a great idea but there was a possibility that they had merely been attracted to the wire electrically in the same way as small pieces of paper are attracted to amber that has been rubbed If then he plunged his copper wire through which the current was passing into powdered glass and also into copper filings to see if they would adhere but in neither case did the particles attach themselves to the wire

Later Arago and another French scientist André Ampère continuing the experiments found that the magnetising of an iron or steel needle was much more effective when the needle was placed inside a spiral coil of wire through which a current was passing and Faraday developed this idea of magnetising iron by winding a coil of wire round it They also found that the magnetism was permanent in the case of a steel needle but existed only while the current was actually flowing in the case of soft iron

Here was the beginning of the electro magnet as we know it to day not only in such small and simple devices as the electric bell but in powerful electric motors and in those giant magnets which are more and more coming into use in industry and a number of examples of which are shown in the photographs on these pages

The enormous value of the power to make and unmake a magnet at will can be easily understood in the case of these giant magnets For example they are used for breaking up old iron and scrap metal of all kinds in a tenth of the time that used to be required for such work The current is turned on the core becomes a magnet and lifts up a heavy steel ball known as a skull cracker to a great height over the scrap metal Then the current is turned off the huge ball weighing many tons falls with a crash on the metal old engines and so on and smashes them in a way nothing else could The magnet is then lowered by a crane the current turned on and the ball is once more held by magnetism and carried up ready for the next fall Some of these balls weigh as much as six tons so that the force with which they fall can be imagined

For loading or unloading iron and steel whether in the form of ingots bars wheel tires or smaller pieces of metal right down to iron and steel filings there is no other method so effective as that in which the giant electro magnet is used Iron and steel filings can not only be lifted but sorted from dust and other rubbish

A magnet between five and six feet in diameter and weighing about three tons can lift thirty tons or more at a time and the great value of the magnet is that it merely has to be let down into the metal and then raised and swung to the required position There is no preliminary tying up or hooking on of the iron bars or other articles that are being handled

Such magnets which are of mushroom or bell form have the coil placed round a central core and they can be made water tight for use under water Their great value in such an awkward situation can be appreciated

But perhaps in no branch of industry is their value greater than at the huge blast furnaces They not only smash up the scrap iron and lift pieces which are too large to be shovelled up in the ordinary way but they can handle plates and bars of metal which are too hot to be touched

One of these gigantic electro magnets for instance is let down on a sow and pigs of iron only just set and lifts the whole hot mass weighing many tons from the moulds into which the molten metal was run

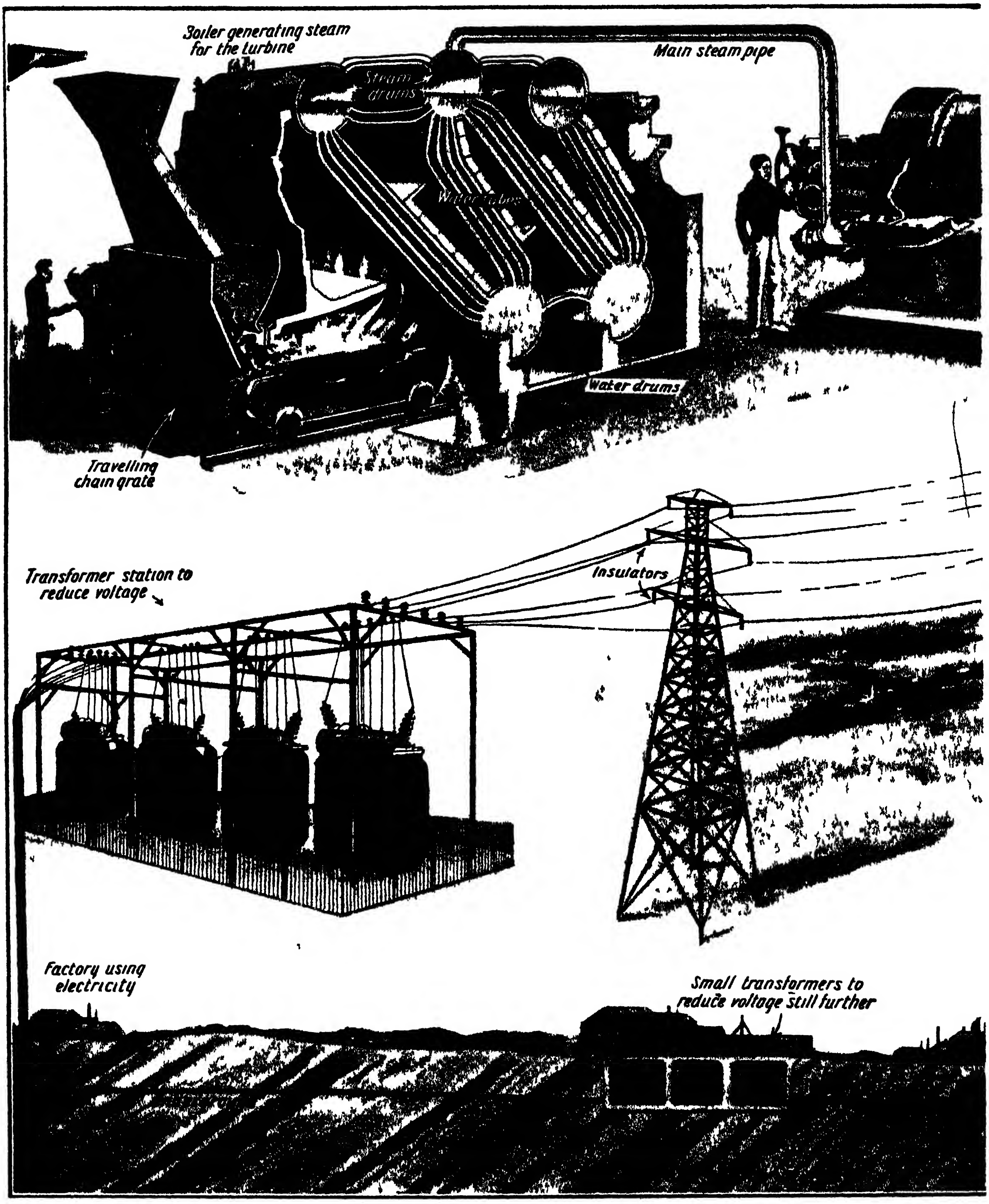
Of course the electro magnet is used in all sorts of smaller ways It can draw fragments of iron or steel from the eye Indeed an eye magnet is now a regular part of every hospital's equipment and of the first aid department of every big engineering works.

A powerful electro-magnet being used to remove a huge heap of scrap iron It moves to and fro over the heap on a crane

A POWERFUL MAGNET IN A BIG RAILWAY WORKS

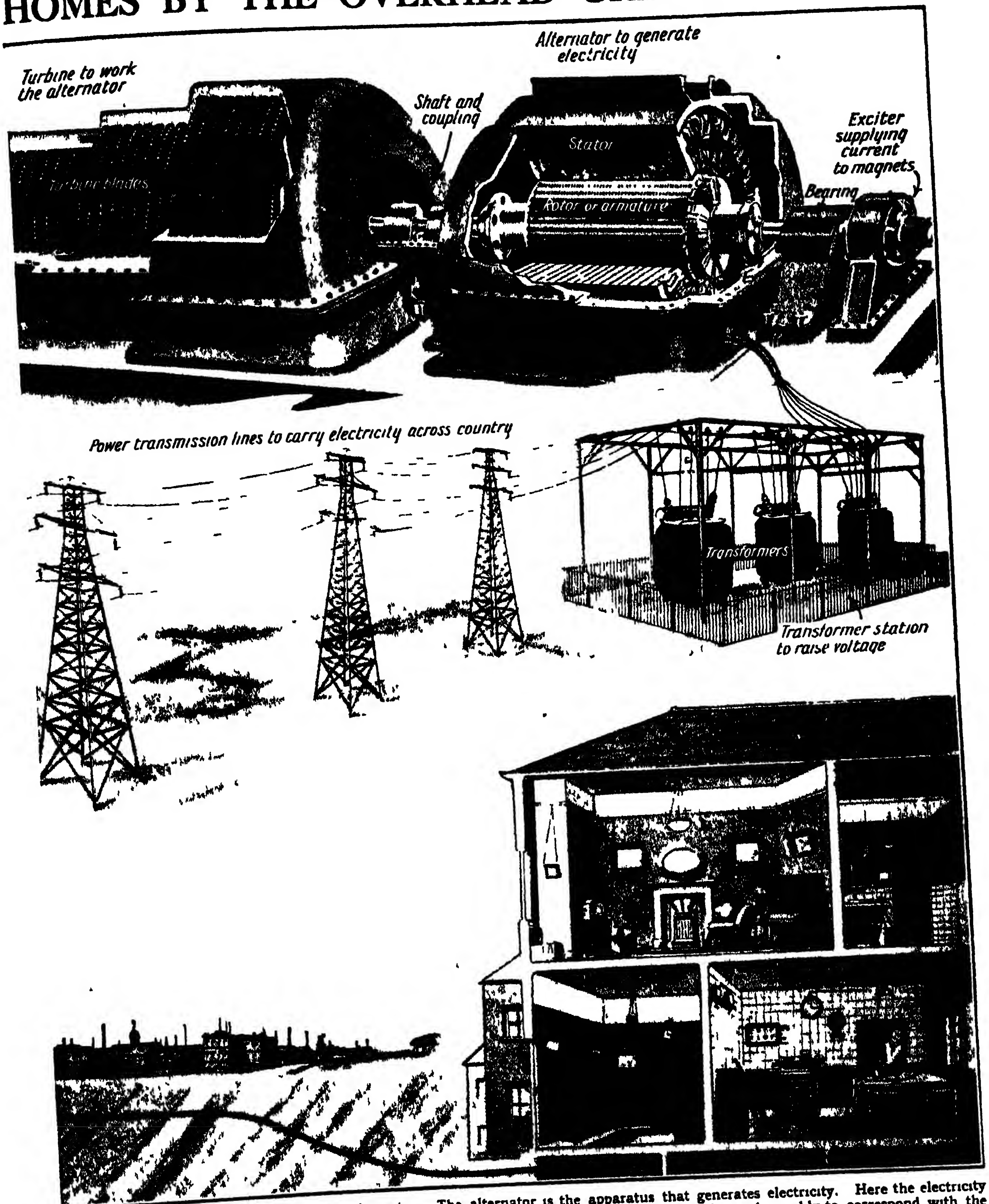
The great value of the electro-magnet for lifting iron and steel goods is that it is convenient and effective, no matter what the shape or size of the articles may be. Large ingots, tubes, girders, locomotive tyres, scrap iron, right down to iron and steel filings, can be raised and moved with equal facility. In this picture we see a great electro-magnet suspended from a massive crane lifting a load of tyres at the Crewe works of the Midland Region of British Railways. The magnet is simply lowered on to the tyres and then, as it is raised, carries them up with it. When it has them over the truck into which they are to be loaded, it is lowered and the current is switched off, releasing the tyres, which are thus placed in the truck as safely and easily as we could put half-a-dozen matches in a box.

HOW ELECTRICITY IS BROUGHT TO OUR



England is fast becoming an all-electric country, for the grid system is spreading wider and wider over the land, and before many years have passed there will scarcely be a village that will not be able to have electricity for lighting, cooking and heating. This system is called the grid system because the whole country is being covered by a grid or network of wires, which will carry the electricity from a few huge power stations to distributing centres, and thence to the homes of the people. We are really at the beginning of the all-electric age. In this picture, which runs across the two pages, we see how electricity is made and conveyed across country to our homes. In the top left-hand corner coal is being supplied to the furnace of a large boiler, which generates steam. This passes from the boiler to the engine, where it presses upon thousands of blades fastened into the cylinder or rotor of a turbine engine, and turns

HOMES BY THE OVERHEAD GRID SYSTEM



this, and with it a shaft connected with an alternator. The alternator is the apparatus that generates electricity. Here the electricity
is produced by induction and passes to a transformer station where the voltage, which may be said roughly to correspond with the
pressure of a water supply, is raised The electricity at high voltage is then carried across country by cables supported on the tall towers and
poles which we see rising in all parts of the country. At another transforming station the voltage is reduced and then passes to an under-
ground cable by which it is carried into the cities and towns and under the streets to our houses. On its way it may be tapped by factories
which reduce the voltage still more by their own transformers In the town the voltage is lowered till it is right for use in our homes. In the
bottom right-hand corner we see an all-electric house where cooking, heating, lighting, ironing and cleaning are all done by electricity

MAKING GLASS & BLOWING IT INTO SHAPE

Glass-making is a very ancient art, and the manufacture to-day is carried on in much the same way as it has been for centuries. Here a pot in the furnace is being loaded with raw materials—sand, potash, and oxide of lead

In this picture the molten glass made from the fusing of the raw materials is being gathered on the end of a blowing or shaping tube

The molten glass on the end of the tube is now marvered or rolled to and fro on a metal table to get it into a rough shape before blowing

Here the workman is blowing the molten glass on the end of the tube to form the bowl of a wine-glass. Great skill is needed

Having blown the bowl the workman is now shearing or cutting the rim level. The stem and foot are already in place. Of course, the glass is still plastic

This workman is casting or fixing the foot on the bottom of a jug that has been blown

Here the workman, having blown the glass jug and fixed the foot on the bottom, as shown in the previous picture, is placing a handle on the jug, using a strip of glass that is still plastic

The jug is decorated by cutting a pattern on its sides, a skilled workman holding it against a rapidly revolving wheel. These pictures were taken at the works of James Powell & Sons (Whitefriars) Ltd.

WONDERS of ANIMAL & PLANT LIFE

THE ROMANCE OF A BOX OF DATES

Hundreds of thousands of boxes of dates are sold in England every year, but how many of the people who buy them and enjoy the dates realise the extraordinary romance that centres around the growing of these fruits? Here their very interesting story is told in some detail

ONE of the most valuable food plants in the world is the date palm. It grows in hot dry countries, sending its roots deep down to find water, and requires very little care on the part of man. It begins bearing fruit when it is only seven years old, and it goes on producing clusters of dates for two hundred years.

The crown of feather-like leaves, each upwards of twelve feet in length, which forms at the top of the stem a hundred feet above the ground, provide welcome shade from the hot sun, and almost every part of the plant has some use.

The fruit provides a complete food, it yields a syrup that is used for confections, the stalks of the bunches softened by boiling are used for feeding cattle, a spirit is distilled from the dates which does not come within the prohibition of the Koran against wine, another drink is made from the sap, the conical tuft in the centre of the crown of leaves, which consists of future leaves in their undeveloped state, is eaten as a vegetable, the fibrous parts of the leaves are made into ropes, baskets, mats and panniers, and the inner fibrous bark is used for the cordage of ships navigating the Red Sea. Though the timber of the trunk is useless for planking, it serves well enough for posts and railings, and a farinaceous food something like sago is obtained from the pith.

An Invaluable Boon

Its native land is the North of Africa, and possibly also Arabia and Persia, and it is difficult to know what the people of these arid countries would have done through the centuries for food had it not been for the valuable date palms that grew in the oases.

The plant has been carried to many other parts of the world, but in few areas does it thrive as well as it does in its native home. It now grows and flourishes in California, and its introduction into America is a great romance and a triumph of man.

The Spanish missionaries were the first to grow date trees in California, and they reared these from date stones brought from Spain. We all know that a palm plant can be grown from a date stone, for many people in England grow small palms in flower pots. The stones which the Spanish missionaries planted in California grew into trees, but a curious thing which the Spaniards could not understand was that while the trees formed attractive ornaments to relieve the landscape, only some of them produced fruit, and that fruit was not very good. The rest of the trees merely yielded pollen-bearing flowers.

In the middle of the nineteenth century the Americans determined to make another effort to grow date palms in California which should yield fruit as excellent as that produced in North Africa. They obtained date stones this time not from Spain but from the region of the Persian Gulf. Again the trees grew and flourished, but only a few of them produced any fruit.

What was the explanation of this strange happening? There was no difficulty in growing fruit-bearing date palms in North Africa or Persia; why then could they not be grown in the genial climate of California? Everything was in their favour, and yet the trees would not do the work that was required of them. There must be some secret, and the Americans determined that they would find out what it was.

Gathering dates in a palm grove in Southern Spain

How to Grow Dates

They made a careful study of date cultivation in its native home, and the first thing they discovered was that it was much better to grow the date palms from suckers than from stones. The young trees produce suckers round their base, and the Arabs take these suckers from the best trees and use them to start new trees and plantations. They never plant date stones, for invariably the stones produce fruit-bearing trees and mere pollen-bearing trees in about equal proportions. By taking suckers from the best fruit-bearing palms the Arabs are able to avoid growing a large number of useless plants.

Growing dates is something like growing apples in England. The gardener does not plant pips in order to get a tree producing the apples he wants. He takes a bud from a suitable apple tree and grafts it on another tree from which the branches have been cut away. This tree is called the stock, and the bud grows till the stock has developed into a tree like that from which the bud was taken.

Just as apple pips do not produce trees yielding the same excellent fruit as their parent, so date stones do not always grow into trees yielding the excellent fruit of their parent trees. The Arabs discovered this fact long ago, although they did not know the reason for it.

The Americans now determined to grow date palms from suckers taken from the best fruit-bearing trees; but this, of course, was a much more difficult business than growing trees from seed. Anyone can get a date stone and plant it, but to obtain living suckers and keep them alive while they travel half across the world, and then rear them successfully, requires a great deal of care.

Many attempts were made towards the end of the nineteenth century, but they failed in almost every case. A few trees, however, flourished and produced excellent fruit, which made it clear that date palms yielding good dates could be grown satisfactorily in California.

The Government of the United States now sent an expert to North Africa to study date cultivation there, and to bring back with him suckers from good trees, and at the beginning of the present century success was obtained. The suckers were secured at Biskra, in Algeria, where the finest dates in the world grow, and where there are something like half a million date palm trees growing. Every tree yields between a hundred and two hundred pounds of fruit a year.

The American expert learnt, among other things, that the date palm is a tree with a very curious disposition. It needs a dry, hot climate, but it will not grow in actual desert country; it only thrives in oases, and an old Arab saying expresses the truth very well: "The date palm, the queen of trees, must always have her feet in running water and her head in the burning fire." In other words, the roots of the tree must be where water is found, but the upper part of the tree must be in the hot sunshine. It will not thrive where there is rain and damp in the atmosphere.

Where date palms grow wild there are as many trees yielding pollen-bearing flowers as there are fruit-bearers; but, of course, in countries like North Africa, Arabia and Persia water is a precious material and must not be wasted; there is so little of it. To allow so many pollen-bearing trees to thrive and use up the water would be wasteful, and the Arab cultivators therefore allow only one pollen-bearing palm for every hundred fruit-bearing palms.

A splendid grove of date palms in Southern California trained as short trees from which big crops of fine dates are easily gathered

The date palm, unlike such trees as the oak and beech, does not bear the male and female flowers on the same plant. The pollen-bearing palms are those with the male flowers, which produce the pollen. The trees that yield dates bear the smaller female flowers, and, of course, before fruit can be produced the female flower must be fertilised with pollen from the male flower. None of the fruit-bearing trees could produce fruit at all if their female flowers, at the

right time, did not receive the pollen from the male flowers.

The natural way in which the wild date palm is fertilised is by the wind blowing the pollen from the male pollen-bearing flowers of one tree on to the female flowers of another, and it is to ensure as many as possible of the female flowers being fertilised that so many pollen-bearing trees are produced, far more, indeed, than are really necessary. Nature is very prodigal in such matters. She always produces a vast deal more than is required, in order to be sure that her purpose is carried out.

The people of North Africa, however, many centuries ago, discovered that it was a waste to have an unnecessary number of pollen-bearing date palms occupying the ground, and so they found a way of artificially fertilising the female flowers. By avoiding waste and no longer leaving the fertilisation to chance, they were able to do with far fewer pollen-bearing trees.

The Arabs cut branches with pollen-bearing flowers from the male trees and, climbing up the fruit-bearing palms, tied these branches among the female blossoms. Then, as the trees swayed in the wind, the pollen fell into the clusters of fruit-bearing flowers, and, as a result, these were fertilised and a fine crop of rich dates resulted.

Artificial Fertilisation

Experience brought added skill and now the Arab, instead of tying branches of pollen-bearing flowers to the tree, takes a twig of pollen flowers with him and opening the sheath of fruit flowers slips in the bunch of pollen flowers and ties it securely in position. Then, as the tree is blown in the breeze, the pollen is shaken out and carried to every female flower in the cluster. In this way a splendid crop of dates is procured year after year.

The Americans, learning this method of fertilisation, followed the example of the Arabs, and now they, too, are able to obtain excellent crops of luscious dates.

How important this artificial fertilisation of the date palm is has been proved more than once. A remarkable instance occurred in the year 1800 when the date trees in the neighbourhood of Cairo did not yield a crop of fruit.

The explanation was that the French and Turkish troops had been fighting all over the country in the spring, and field labour of every kind was suspended, including the fertilisation of the date palms. The female trees put forth their bunches of flowers in the usual way, but not one ripened into edible fruit. The wind had scattered the pollen of the male trees all over the country, but there had not been sufficient to reach the germs in the female flowers, and thus ensure fruit forming.

In Persia during a civil war one side chopped down the male date trees of a whole province which they had invaded in order that the fertilisation of the female trees might be stopped and food supplies cut off.

Saving the Pollen

The people of the province, however, anticipating such action, had very carefully gathered a quantity of pollen, which they kept in closed vessels, and they were thus able despite the action of the enemy, to impregnate their trees and produce a crop of fruit for harvesting when the enemy had passed on.

Date palms in California with male pollen branches tied on the trees and protected from the wind by canvas bags. The pollen falls on the female flowers, fertilising them and producing big bunches of dates

An Italian poet of the fifteenth century tells us of a female date tree which had stood lonely and barren near Otranto, until one season a favouring wind wafted towards it the pollen of a male tree that grew sixty miles away.

The Great Importance of the Date

The enormous importance of the date in Eastern countries, and the high esteem in which it was held, is clearly shown by references to it in the Bible. Wherever the palm is mentioned it is the date palm that is referred to. We are told that "the righteous shall flourish like the palm tree"; that judges dispensed justice under palm trees; that the palm was the symbol of victory; and that in a war, to capture a city of palm trees was regarded as a great success.

Mohammed, too, uses the palm as a symbol of veneration and compares the virtuous and generous man with the date palm, declaring that "he stands erect before his lord, and in every action he follows the impulse received from above."

We can quite understand all this honour being done to a tree which rears its stem and expands its broad and beautiful shade where nothing else will grow, to shelter man from the burning rays of the Sun and to give him food.

The date palm is a very slow-growing tree, and even in a good soil and a congenial climate old trees do not gain more than a foot in height in five years. It is said that some of the trees sixty feet high are two or three hundred years old.

The cultivation of the date tree is naturally an object of great importance in Eastern countries, and in some parts of North Africa and in the valleys of the Hejaz it is almost the sole subject of agriculture.

A Palm Tree for a Wife

Date trees pass from one person to another in the course of trade, are handed down from father to son, and are sold in clumps or in single trees. Often the price paid for a wife to her father consists of one or more date trees.

The fruit of the date palm is not the only product of this tree which comes to Europe. A large business is done in exporting palm leaves for use in religious processions, both of Christians and of Jews. We remember how that when Jesus rode into Jerusalem on what we now call Palm Sunday, the people "took branches of palm trees and went forth to meet him," spreading the branches in the roadway.

The stones or kernels which are as hard as horn are carved into beads and strung together to form Paternosters for sale in Catholic countries, and a considerable industry of this kind exists in different parts of North Africa. The stones by the way are also used for another purpose. They are ground up into powder by means of hand-mills and used for food for camels, which eat the stones thus prepared with evident relish.

The date palm is thus venerated by Christians, Jews, and Moslems, and it is interesting to remember that on the coins of the Roman Emperors Vespasian and Titus, Judea was typified by the representation of a palm tree.

WHAT OUR COMMON FOODS ARE MADE OF

The things we eat vary a great deal in food value. Some popular foods contain so little nutriment that they are not worth eating at all. We need, in order that we may sustain a healthy life, certain substances, and these we obtain from certain foods we eat. Protein, which supplies us with nitrogen and builds up our body, can only be manufactured by living plants and animals, and we find it in all sorts of foods, though in varying quantities. White of egg and the casein in milk and cheese are familiar forms of protein. Then we need carbohydrates and fats to give us energy. These are really fuels, and are burnt up in our bodies just as coal is burnt in a steam engine. Starch and sugar are two forms of carbohydrates. We also need water, and a certain amount of mineral matter. In this page we see the proportion of these various substances in milk, bread, mutton, fresh herring, bacon, eggs, bloater, golden syrup, honey, beef and cheese. The nutritional and health-giving value of foods is also governed by their vitamin content, as explained in page 711.

WHY A DOG PANTS & PUTS OUT ITS TONGUE

We must have noticed that when a dog is very hot, as, for example, on a warm summer day, it lies down, opens its mouth and pants. Why does it do this? We do not pant in hot weather. Well, if a body is to remain healthy it must go neither above nor below a certain temperature. Now, in hot weather we are able to keep our bodies cool by perspiration, that is, we give off moisture from glands all over our bodies, then, as this moisture evaporates, it leaves our skins cool. But a dog has sweat glands only on the skin of its footpads, and so it is unable to keep cool by perspiring as we do. It therefore opens its mouth and pants or breathes quickly, in order to get rid of as much moisture as possible by its lungs. That cools it in the same way as perspiring cools us. In ourselves the sweat glands are most numerous in the palms of the hands, the soles of the feet, the forehead and the sides of the nose. That is why when we get hot our hands and feet get very moist and beads of perspiration stand out on our foreheads and noses. Sweat glands are absent from the lips

HOW A MOTH FERTILISES A FLOWER

The field bindweed is fertilised by the convolvulus hawk moth, as shown here At the base of the flower's trumpet there is nectar, and the moth, desiring this nectar, puts its long tongue down as far as it can In doing so its head comes in contact with the anthers or male part of the flower, and the pollen is rubbed off on to the moth's head The moth then flies off to another convo vulus, and as it puts its head in to reach the nectar the pollen on its head is rubbed off on to the stigma or female part of the flower and the result is that the ovary containing the seed bud is fertilised, and seed is produced Later the seed case bursts and the seeds are thrown out

MARVELS of CHEMISTRY & PHYSICS

THE ROMANCE OF THE STETHOSCOPE

If you have been examined by a doctor, you have probably noticed that he took out a little instrument consisting of rubber tubes and ear-pieces, with a little flat piece which he placed against different parts of your body, and carefully listened. The instrument was called a stethoscope, and he was listening to see how your heart was beating, or whether your lungs were working properly. This instrument is of very great importance, and all doctors carry one. The story of how it was invented and how it is used is told in these pages

WE should hardly expect to find anything romantic about a scientific instrument with a forbidding name like stethoscope The word comes from two Greek words, stethos meaning the breast and skopos meaning a watcher and stethoscope is not at all a bad name for the instrument for it does enable the doctor to gain knowledge of what is going on inside our body almost as though he were there watching

In these days no doctor would think of going about without his stethoscope it is an essential part of his equipment and if you have ever had a bad cold or trouble with your chest or heart and the doctor has been called in he has certainly placed his stethoscope against some part of your body and then listened

Yet although the instrument is so important and is used so much it was invented only as recently as 1814 In that year a famous French doctor named René Laennec was walking near the Necker Hospital in Paris which was full of sick and wounded soldiers of Napoleon's Army Laennec always worked hard to help these men many of whom were dying of tuberculosis

As he walked near the hospital he noticed a number of children playing at see saw He watched them and saw that they stopped moving the plank up and down Then one of them placed his ear against the beam at one end while a boy at the other end scratched the wood What could they be doing? Laennec was greatly interested He made inquiries and found that the boy with his ear on the wood at one end could distinctly hear the scratches made by the boy at the other end although these were not at all audible to anybody standing close by The children had made up a code and were sending messages to one another the sounds being transmitted through the timber instead of through the air

This gave Laennec a great idea Why should he not use a wooden tube or cylinder for listening to the sounds produced in the interior of the chest by the action of the heart or lungs

He carried out his idea and had a wooden tube made It was the first stethoscope the world had ever seen Laennec used it and listened to the sounds inside the bodies of his patients but in those early days little was known about what the different sounds meant

In the left-hand picture we see the birth of the stethoscope, which the doctor uses when he sounds our lungs The instrument was invented by the French doctor, Laennec, who noticed two boys sending messages through a see-saw While one listened at one end his companion scratched on the plank at the other end. This gave the idea for the stethoscope which doctors now use so much In the right-hand picture we see little Leopold Auenbrugger watching his father, an innkeeper, tapping the wooden casks to see how much wine they contained. When Leopold grew up and became a doctor he tapped on people's bodies to learn their internal condition, and this is still done by doctors when they examine us to find out if fluid has formed on our chests

LISTENING TO THE LUNGS WITH A STETHOSCOPE

When a doctor wants to know the condition of a person's lungs or heart, he places one end of an instrument, called a stethoscope, against the body and listens by means of ear-pieces. This instrument, by shutting off outside noises so that any sound made by the lungs or other organs in the body can be heard distinctly, enables the doctor to learn a great deal about the state of health of a patient. The stethoscope is a very important instrument, and there is a statue of its inventor, Dr. René Laennec, standing in the Market Place of Quimper, his birthplace in Brittany. How a stethoscope amplifies sounds inside the body is illustrated in the opposite page.

Laennec, however, made very careful notes, and then, when any patients died, and there was an examination of their bodies, he tried to link up the sounds he had heard with the condition of the inside of the patient's body. A few years later he published a book which he called "On Auscultation." This difficult word simply means the act of listening, and is made up from a Latin word meaning to listen.

The art of listening is very important in the examination of a patient when a doctor is trying to find out what is wrong with him. This was recognised even before Laennec's time.

Early in the eighteenth century there was an inn-keeper at Graz in Austria, who had a son named Leopold. The boy used to help his father in the various duties of the inn, and he often noticed that his father went to the large wooden casks in which the wine was kept and, putting his ear against the wood, slapped the casks.

Young Leopold was interested, and soon found out that his father did this in order to discover how much wine there was in each cask. It was impossible to see through the wood, but if the cask was set on end, the ear placed close up to the side and the cask slapped at various places from the top down, it was easy to find the level of the wine.

The note was low where there was only air inside, but when the place was reached where the wine happened to be, the note suddenly became much more highly pitched.

Years afterwards, Leopold Auenbrugger, for that was the boy's name, became a fashionable doctor, and official physician to the Empress Maria Theresa. Then he suddenly remembered what he had seen at the inn.

One day, when the body of a patient who had died was opened, the chest was found to be full of fluid. "If I had only known," thought Dr. Auenbrugger, "I might have saved this patient's life." But he had never suspected the presence of the fluid.

Was there no way, he asked himself, of making the discovery while the patient was alive? Then the tapping of the casks flashed upon his memory. He decided to try the same thing with his patients. He did so, and the plan was a splendid success. He called it percussion, which simply means a beating or striking, and he wrote a book to show its value and importance.

Ever since that time doctors have carried out the practice and found it exceedingly useful. It is one of the regular methods of examining a patient, and probably a good many readers have had it practised on them.

It is very interesting to think that from the observation of two boys came these great discoveries in connection with the examination of the human body. Now, in addition to the stethoscope and the tapping, we have a still more valuable means of examining the inside of a patient's body. An X-ray photograph is taken, and by this means much can be learnt that cannot be known otherwise.

The use of the stethoscope has been greatly developed in modern times. Now, instead of a simple hollow wooden tube, the stethoscope consists of a chest-piece from which lead two rubber tubes with bone or metal ear-pieces.

Experience with such stethoscopes enables the doctor, as a rule, to discount anything that is outside the body, but the danger of overlooking faint sounds or of confusion from sounds produced by the rubbing of the clothing makes it necessary to have the chest exposed as thoroughly as possible when examining the heart or lungs. Two sounds can be heard from a normal heart—"lub—dup."

An ear-trumpet, used by deaf people, is only a form of stethoscope, and, of course, a megaphone or speaking-trumpet is of the same nature.

The stethoscope is extensively used in testing welded metal. We all know how when a long-distance train comes to rest at a railway station, very often a man goes up the train and taps the wheels with a hammer. He does this in order to discover if they are sound.

Welded metal joints used to be tested in the same way, but a blow with an ordinary hammer loud enough to give the required information, is liable to injure the weld. Now the stethoscope is used and only a gentle tap is given.

This picture-diagram shows how the doctor uses a stethoscope to listen to his patient's heartbeats. The vibrations from the heart pass through the body and are picked up by the diaphragm of the stethoscope (lower circle). The sound is then carried through the tube to the ear-piece and is registered on the doctor's ear-drum (upper circle).

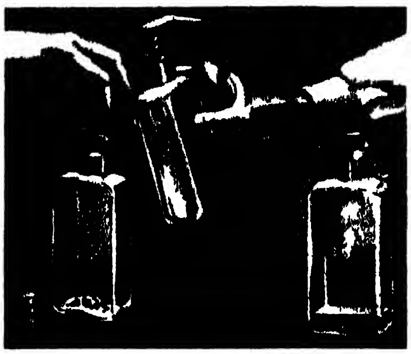
SOME SIMPLE EXPERIMENTS WITH AMMONIA

It is always interesting to carry out experiments with familiar materials such as we are used to in the home. In some ways this is more fascinating than when we do elaborate experiments in the school laboratory with a variety of chemicals that have been specially purchased for the purpose.

In other parts of this book many experiments are described which can be carried out with such very familiar substances as sugar, salt and soda. Another material which is found in most homes is ammonia, or rather a solution of ammonia, for ammonia itself is a gas, colourless and very pungent to the nose. It is, of course, the basis of smelling salts which when they are fresh make us jump or start if we take a good sniff from the bottle.

What Ammonia Really Is

Ammonia is a chemical compound made up of nitrogen and hydrogen gases, each molecule of which contains one atom of nitrogen and three atoms of hydrogen. Ammonia gas is very soluble in water, and at the ordinary temperature and pressure of the atmosphere one volume of water will absorb about 1,300 volumes of ammonia.



An experiment showing that ammonia does not act on copper filings till air is admitted to them

Now, having learnt a good deal about the substance with which we are going to deal, let us proceed with our experiments.

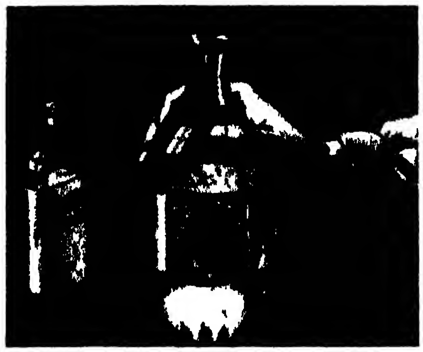
First of all we take a small bottle and fill it with liquid ammonia such as is kept for household purposes. Then we drop into it a few bright copper turnings or filings that we can obtain at any place where metal is worked. The local ironmonger could probably supply us with a little. When putting the copper turnings into the bottle of ammonia we must be careful to drop them in gently so that no air gets in.

A Striking Change

Having prepared our bottle we cork it tightly and then leave it for some hours. On returning to the bottle we find it looks exactly as it did when we first put the cork in. The ammonia solution is without colour and the copper turnings are lying at the bottom of the bottle unchanged.

Now let us pour out of the bottle most of the liquid, leaving only a little at the bottom. Cork up the bottle again and shake it well. Almost directly the liquid begins to turn blue. What is the cause of the change?

Well, what has happened is this. The oxygen of the air which entered the bottle when we poured out most of the liquid ammonia together with the ammonia has acted on the copper, forming a new chemical compound which is known to chemists as ammoniated copper hydroxide, and it is this which gives the liquid its blue colour. When the bottle was full to the brim of ammonia there was no air and therefore no oxygen to assist in the chemical change.



A solution of ammonia appears to boil directly heat is applied

Bubbles of Gas

Let us carry out another simple experiment with ammonia which may cause us some surprise. In a glass flask, which should be made of fairly thick glass so as not to crack easily when we heat it, we place a strong solution of ammonia so as to have the flask about half full. We hold the flask over the flame of a spirit lamp or small gas ring. Almost immediately the liquid appears to be boiling and bubbles rise rapidly, exactly as they do when water is boiling. The liquid is not really boiling, but owing to the application of warmth a certain amount of ammonia gas is at once given off. The water, when warm, will not hold so much of the gas in solution as when it is cold. We can know that ammonia gas is being given off by putting our nose near the mouth of the flask or bottle; we shall smell it.

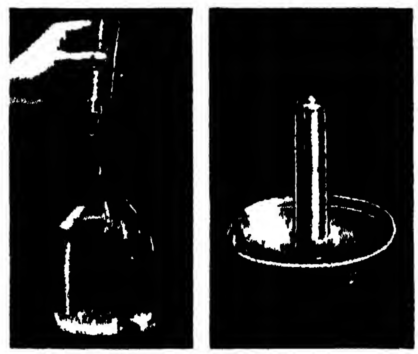
A piece of ice placed in a tube of ammonia gas dissolves the gas and is itself melted

Let us perform the same experiment again, but this time we put a perforated cork in the neck of the flask, with a short piece of glass tube stuck through the cork to act as a delivery tube. We should see that this is gas-tight by putting wax or grease all round where the pipe comes out of the cork.

Collecting the Ammonia

Directly we warm the flask the bubbles rise again, and the ammonia gas as it is given off passes through the delivery tube into an inverted test-tube which we hold over the outlet. In a few moments the test-tube is filled with ammonia gas. We hold the test-tube upside-down, because ammonia gas is much lighter than air and therefore rises.

Having our test-tube full of the gas we next set it mouth downwards in a basin of water. Almost directly the water begins to dissolve the ammonia, and although we cannot see it doing this we know that it is happening because the water rises in the test-tube, driven up by the pressure of the atmosphere outside on the water in the basin.



Collecting ammonia gas in a test-tube and seeing the water rise as the gas is rapidly dissolved

A final experiment may be carried out with ammonia. We collect a test-tube of ammonia as in the last experiment, and then, while the tube is full of the gas, place in it a small piece of ice, closing the mouth of the tube with our fingers so that the gas may not be able to escape.

Ice Absorbs Ammonia

Very soon the ice will be melted, and a solution of ammonia formed, for the tendency of water to absorb ammonia gas applies even when the water is frozen solid. As the outer surface of the ice absorbs the gas sufficient heat is developed to thaw a layer and the water so produced absorbs more ammonia, producing more heat, and so the action goes on, till the small piece of ice is completely melted.

THE MYSTERIOUS CONE OF LIGHT

A little-known phenomenon of the sky is that which is called by astronomers the Zodiacal Light. It consists of a very faint cone of light seen at evening after the Sun has gone down, and in the early morning before the Sun has risen, and it is sometimes observed in England. Here we read about this strange sight.

THERE is a strange sight which we may sometimes see in the evening or early morning. In the Northern Hemisphere it is most often seen in the evening during the months of February and March, and in the morning during October and November. In the evening it appears in the western sky, and in the morning before dawn in the eastern sky.

It consists of a faint cone of light, its apex resting about half way between the horizon and the zenith, which is the point over our heads. Generally it is fainter than the Milky Way, and is not very often observed at all. Any moonlight will obscure it. It is slanting, and is rather like the beam of a very weak searchlight, except that the broader part rests on the horizon and the point is up in the sky.

What appears to be the apex of the cone, however, is not really the limit of the Zodiacal Light, as it is called, for men of science tell us that this is continued as a very weak trail of light to the opposite side of the sky, where it again broadens out.

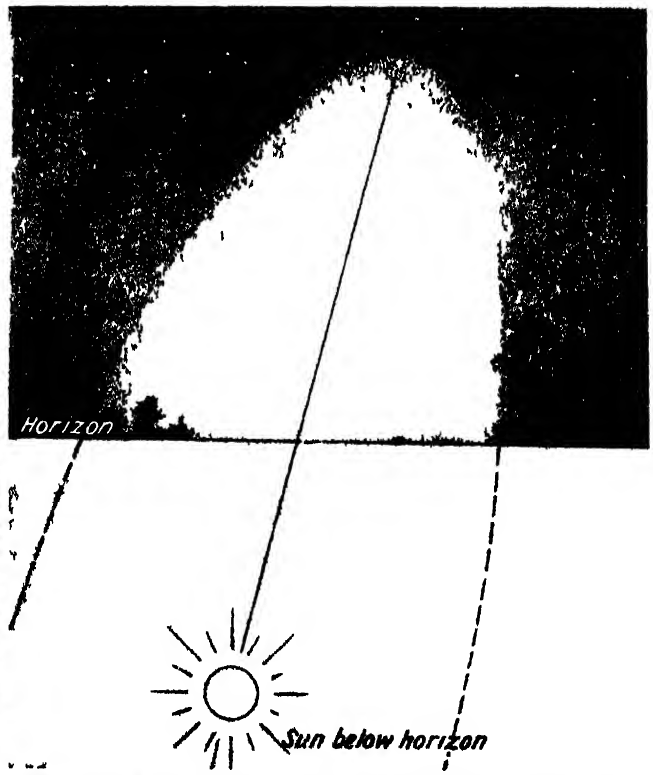
What is this strange light? Scientists are not agreed. It used to be thought that it was a kind of tail to the Earth, something like the tail of a comet. It is now believed by some to be the reflection of light on a ring of minute particles that surround the Sun very much in the same way as Saturn's rings surround that planet.

Other astronomers believe that it is the reflection of sunlight on masses of hydrogen and helium gas high up in our atmosphere, while others again think it is due to particles expelled electrically from the Sun's poles, or in other words it is an extension of the Sun's corona, the glowing halo that is seen during an eclipse to surround the Sun. The ring theory is believed to be the most probable explanation of the Zodiacal Light. When the light is analysed by the spectroscope it is found to be identical with sunlight.

The Zodiacal Light is so called because formerly it was only seen in the Zodiac, the belt of constellations that the Sun appears to pass through. It is most often observed in the Tropics. There it is visible after twilight on any clear moonless evening and before twilight on any clear moonless morning, and is more vertical than when it is observed in northern latitudes like that of England. It is always drawn out in the direction of the ecliptic, that is the Sun's apparent orbit in the sky.

Connected with the Zodiacal Light in some way, though far less distinct, is what is known as the Gegenschein, or counter glow. Gegenschein is made up of two German words meaning opposite and shining, and it is a faint luminous patch in the sky on the ecliptic in a direction opposite to the Sun. It cannot be seen in June, July, December or January, because in those months the Milky Way obscures it.

The counter glow is so faint that no definite outline can be detected, but it covers a large area of the sky. No explanation of it can be given, although some have thought that it is caused by reflection from small meteoric particles.



These pictures show the Zodiacal Light as it is sometimes seen in England, though in the pictures the brightness of the light is somewhat exaggerated. It is generally very faint and consists of a cone pointing slantingwise. The appearance is something like the beam of a very weak searchlight inverted. The Editor of this book has seen it at Cambridge. The picture on the left shows its appearance, and that on the right gives the possible explanation. The Zodiacal Light is supposed to be a reflection of sunlight on minute particles of matter surrounding the Sun. A line drawn from the apex of the cone through its centre would lead to the Sun below the horizon.

THE MYSTERY RAYS ON THE MOON'S FACE

Of the many strange features that are seen on the surface of the Moon by means of the telescope the most mysterious is the series of bright streaks or rays that diverge from many of the big craters.

The most noticeable of these rays reach out in all directions from the great crater Tycho. In this group more than a hundred streaks have been counted, and some of them run in a direct line through all kinds of inequalities for a distance of 600 miles or more from the crater. The rays or streaks running from Copernicus, though not so distinct or long, are even greater in number.

The fact that these streaks are seen only radiating from the craters of the Moon suggests that their origin has some connection with that of the craters. The only astronomers who have given any exhaustive explanation of the rays are James Nasmyth and James Carpenter, who together wrote a book on the Moon, one of the best that have been published. The photographs illustrating this chapter are taken from the book.

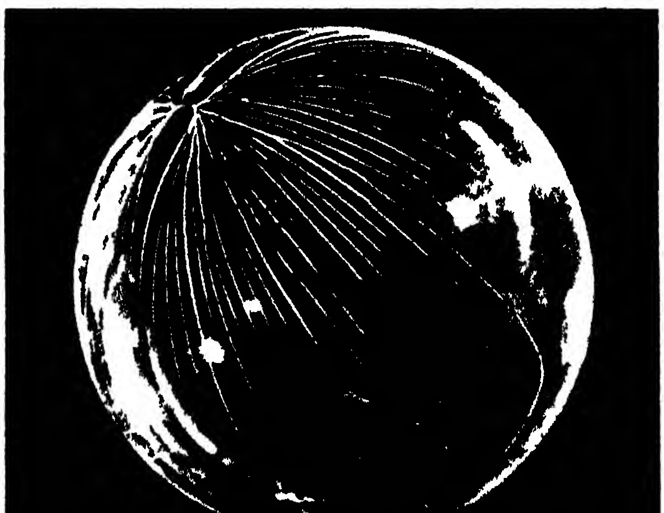
The fact that the bright streaks are invariably found diverging from a crater, say the authors, impressively indicates a close relationship or community of origin between the two phenomena; they are obviously the result of one and the same causative action. It is no less clear that the actuating cause or prime agency must have been very deep-seated and of enormous disruptive power to have operated over such vast areas as those through which many of the streaks extend.

An Interesting Experiment.

With a view of illustrating experimentally what they conceived to have been the nature of this actuating cause the astronomers took a glass globe, and having filled it with water and hermetically sealed it they plunged it into a warm bath. The result was that the enclosed water, expanding at a greater rate than the glass, exerted a disruptive force on the interior surface of the globe, the consequence being that at the point of least resistance the glass was rent by a large number of cracks diverging in every direction from the focus of disruption.

As can be seen from the photograph of the glass globe on this page the result is a strikingly similar counterpart of the diverging streak system proceeding from Tycho and other lunar craters. The photograph of the Moon showing Tycho at the top left hand with his streaks is certainly remarkably like the fractured glass ball. As the astronomers say, it seems impossible to resist the conclusion that the disruptive action which originated the cracks in the glass ball was similar to that which caused the cracks on the Moon.

A photograph of the full Moon, showing the crater Tycho near the top with the mysterious bright streaks radiating in all directions. This photograph shows the Moon as seen through an astronomical telescope that is inverted



A glass globe which was cracked by internal pressure, showing bright streaks radiating from a central point in the same way as the Moon's streaks radiate from its craters

Nasmyth and Carpenter go on to explain that the disruptive force in the case of the Moon was due to the expansion of the molten substances inside during the early ages of the Moon's history. The expansion rent the solid crust of the Moon and produced a system of radiating fissures which at once afforded an outlet for the molten matter beneath. This made its appearance on the surface simultaneously along the inner course of every crack and irrespective of all surface inequalities or irregularities. The up-flowing lava spread in both directions sideways and so produced streaks of greater width than the cracks or fissures themselves.

When the Ice Cracks.

As an illustration of this action the astronomers refer to the behaviour of water beneath the ice of a frozen pond. When the ice is fractured by some concentrated pressure or by a blow, cracks radiate from the point of pressure, and up through these the water immediately issues, making its appearance on the surface of the ice along the entire course of every crack. On reaching the surface it spreads out on both sides to a width far exceeding that of the crack itself.

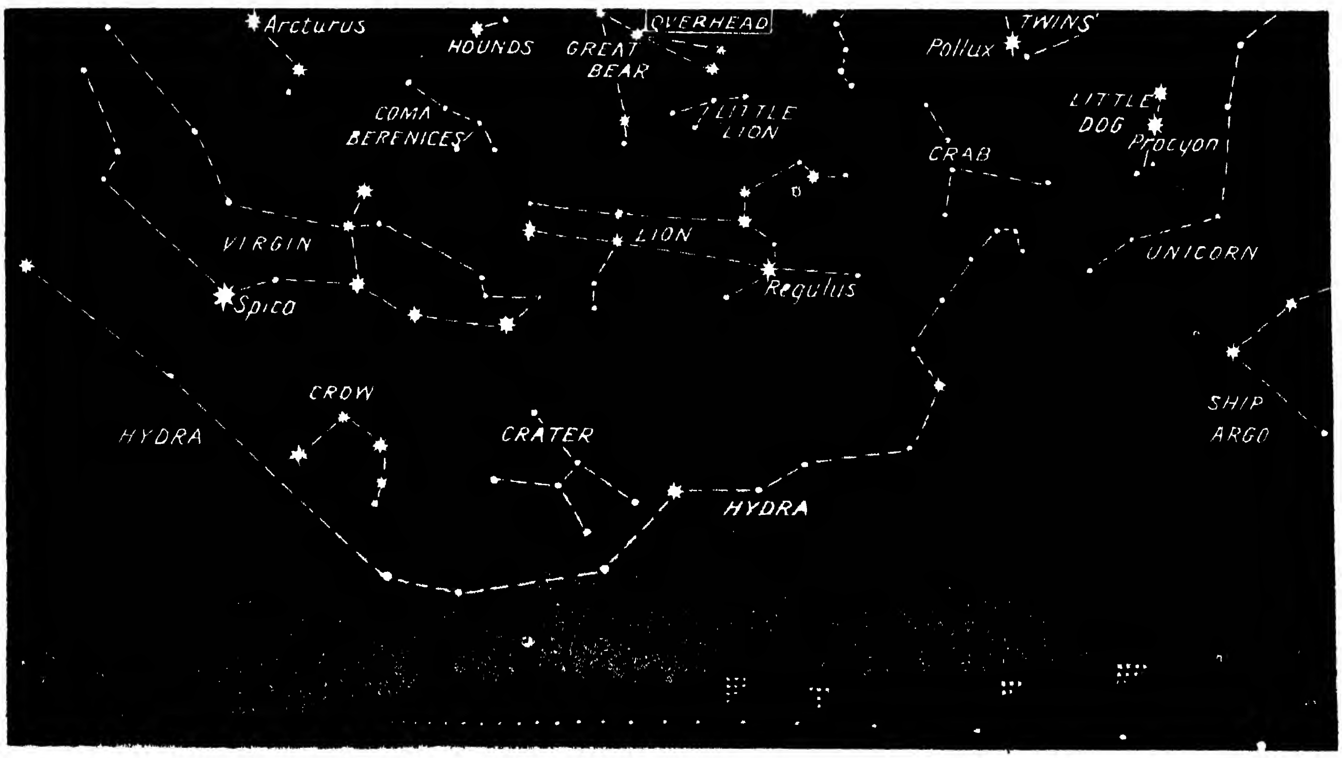
Certainly the explanation seems a plausible one, and the most likely of those that have been given for the strange streaks. Some have tried to explain them by suggesting that they are streams of lava which have issued from the crater at the centre of their divergence and flowed over the Moon's surface. But this seems a very unlikely explanation, for lava would not flow in streams of nearly equal width in all directions for hundreds of miles, up and down hill, over mountain and plain.

Another reason for disbelieving the lava theory is that so far as can be seen the streaks throw no shadows, as they would certainly do if they consisted of piled-up lava.

This theory of the cracking of the Moon's surface through interior pressure is quite consistent with the vapour theory briefly referred to on Page 311. Some astronomers think that the brightness may be due to vapours still rising, while others believe that the brightness is due to vapours of the past which have condensed and formed light-coloured deposits.

HOW WE MAY RECOGNISE THE CONSTELLATIONS

The people in olden times who spent their nights in the open air with the great canopy of heaven spread overhead, were keen astronomers, and it was they who named so many of the constellations, likening them in their fancy to animals and people and other things with which they were familiar. On this page we see the principal constellations as they appear to the naked eye in England. Here we are shown the chief stars looking directly north at nine o clock in the middle of April. The faint, cloudy band which can be seen on the left and which goes across the heavens is, of course, the Milky Way, which, though it appears like a wisp of cloud, is really made up of hundreds of millions of glowing suns. It can always be recognised on a clear night, and it is a wonderful thought as we look at it to realise that it is really an incredibly vast universe to which our solar system with the Earth and the other planets belong.



This picture shows the heavens looking south at nine o clock in the middle of April. The constellation of the Great Bear, part of which is shown, is directly overhead, and near the horizon is the long, straggling constellation of Hydra. Of course, we want a clear night when the Moon is new or merely a crescent in order to see the full glory of the starry sky. When the Moon is brilliant its light dims that of many of the stars, and it is not so easy to recognise the constellations. Of course, just as it is interesting to pick out the constellations and know them by name when we see them, it is still more fascinating to watch the heavens regularly through the year and note their changing appearance. In other parts of this book we see the sky looking north and south at other seasons of the year.

A HOME-MADE TRANSIT INSTRUMENT

We tell the time by our clocks and watches and these instruments are quite accurate enough for ordinary purposes. But as we know they often get fast or slow, and it is absolutely necessary, if our clocks and watches are to be set right from time to time, that there should be some way of knowing what the real time is. It is astronomers who discover this for us.

At Greenwich and other observatories there are very accurate clocks, but even these have to be watched to see that they do not get wrong by the fraction of a second.

How is the true time ascertained? Well, it is discovered day by day and night by night by watching the transit of a heavenly body across a meridian or imaginary line in the sky. At midday the transit of the Sun across the meridian of Greenwich is observed, but even more accurate time is found by watching the transit of a star, as the star's arrival each 24 hours does not vary as does the Sun's.

The transit instrument used by astronomers is a complicated apparatus, consisting of a telescope mounted so as to lie north and south and swing round in the true plane of the meridian. It is supported on two pillars by means of an axis that lies exactly east and west.

Inside the telescope tube at the end is a circle with tiny lines running across it. Sometimes the lines are stretched threads of spider silk, and at other times they are fine lines ruled on a thin plate of very clear glass with a diamond point. This object is known as a reticle, a name derived from the Latin word "rete," meaning "a net."

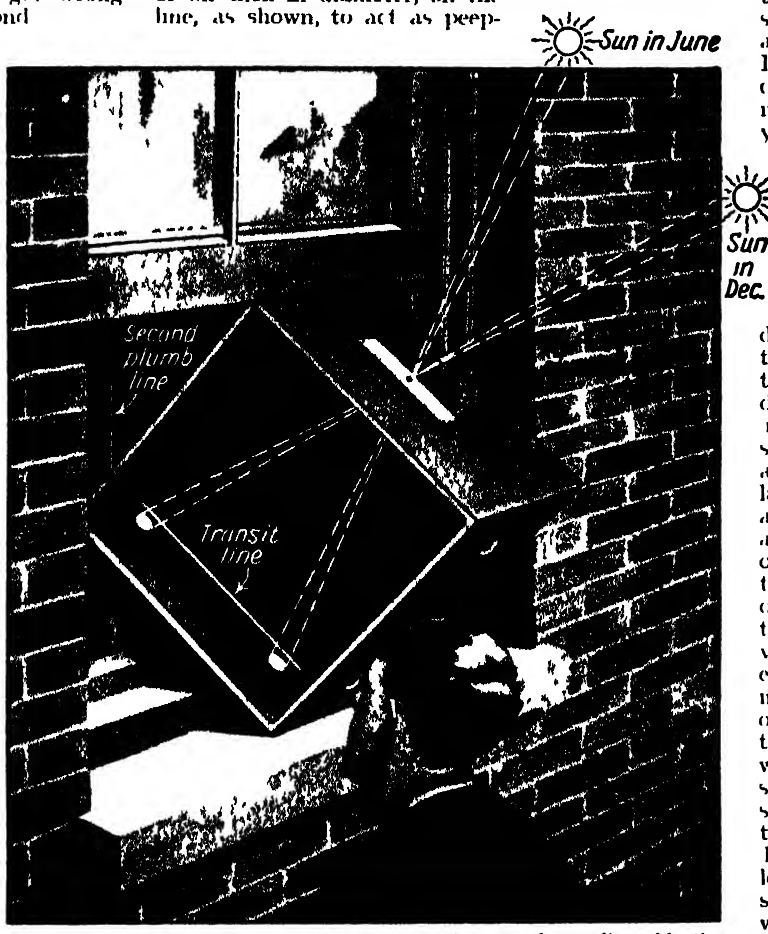
The passage of a star over the line of the meridian can then be very accurately noted, and from the transit the astronomical clock or chronometer at the observatory is checked. The transit of the Sun is observed in a similar way.

Of course we cannot without great skill and expense make a transit instrument such as is used at an observatory, but we can at very little cost make a simple transit instrument for ourselves, and use it for observing the passage of the Sun across the meridian. This will give us the exact time within a few seconds.

Choose a window facing south which has a clear open view from near the horizon almost up to the zenith or point overhead. Now hang two plumb lines exactly in the meridian by the method described on page 244. One should be inside the room and the other outside, as shown in the picture.

In line with these plumb lines, and between them, firmly fix to the window casing a strong wooden box about 18 inches square. Then, by sighting along the two plumb lines, draw a pencil mark round the outside of the box to indicate in a rough way the meridian.

Next bore two holes, three quarters of an inch in diameter, on the line, as shown, to act as peep-holes. Then bore a third hole in the same plane near the middle of the upper face of the box. Nail over this upper hole a thin strip of tin or zinc or sheet lead, and make in the metal a clean pin hole, which shall be in the plane of the two plumb lines.



This simple instrument, which any boy or girl can make, will enable the amateur astronomer to find the time of true noon by watching the sun cross the meridian

One other line must be drawn this time inside the box on the lower face. We make this exactly in the plane of the plumb lines by sighting past these and through the holes, taking a sight through one hole in order to check the line as seen through the other.

All is now ready for us to observe the Sun's transit across the meridian. Just before noon if we peep through one of the holes we shall see inside the box an image of the Sun not quite a quarter of an inch in diameter on the west of the line which we drew.

Now, if we watch we shall see this image of the Sun slowly creep towards the transit line. The moment it first touches the line we look at the time by our watch. Rather more than a minute afterwards the line will bisect the image of the Sun. We again note the time. Then when the image has passed and is touching the line on the other side we take the time once more.

We now take the average of these three times, and add or subtract what is known as the equation of time. It is no use to give the equation of time here, as it varies for different years, but we can find it for ourselves for any day of the year under that date in the front part of "Whitaker's Almanack," which we can see at any library.

The length of the day varies at different times of the year, owing to the fact that the Sun does not always arrive at the meridian at the same time, but our clocks and watches are regulated to run according to an average which makes all the days of the year of equal length. Sometimes the Sun is ahead of the clock and sometimes behind it. This variation is called the equation of time, and so in finding by means of our transit instrument the time of true noon, we must add or subtract so many minutes and seconds according to the table in the almanack. The result will give us local mean time within a second or two; that is, we shall know the exact time for the place where we are making our observation, which will, of course, be different from Greenwich Time, unless we are actually somewhere on the meridian of Greenwich. Everything depends upon our having fixed our plumb lines and drawn our lines on the box accurately.

If we are far from Greenwich then, of course, we shall have to make another adjustment, adding or subtracting so many minutes and seconds for the difference between Greenwich Time and local time. In the British Isles, however, this adjustment is very small.

All this may seem rather complicated, but any intelligent boy or girl who is interested in the sky and such things as the mystery of time, will find the experiment described a very interesting one to carry out.

ROMANCE of BRITISH HISTORY

THE LITTLE PRINCES IN THE TOWER

The story of the little princes who lost their lives in the Tower of London as a result of the treachery of Richard Crookback is one of the saddest incidents in English history. The only satisfactory thing in the whole story is that Richard in the long run gained nothing from his faithlessness and cruelty, for he had no sooner won the crown by foul means than he lost both it and his life on the battlefield of Bosworth. The story of the little princes is told in these pages

After the death of Henry the Sixth in the Tower, the Yorkist king Edward the Fourth remained on the throne in reasonable security. He had two brothers, George, Duke of Clarence, and Richard, Duke of Gloucester, who is often called Crookback owing to the fact, it is said, that one shoulder was slightly higher than the other, which gave him a bent appearance. His left arm also was somewhat withered.

It is very difficult to learn the truth about some of these characters in early history, for their enemies made them out worse than they were, and their friends made them out better. One description of Richard says:

"There never was in any man a greater uniformity of body and mind, both of them equally deformed. Of body he was but low, crook-backed, hook-shouldered, splay-footed and goggle-eyed; his face little and round, his complexion swarthy, his left arm from his birth dry and withered. Those vices which in other men are passions, in him were habits, and his cruelty was not upon occasion but natural."

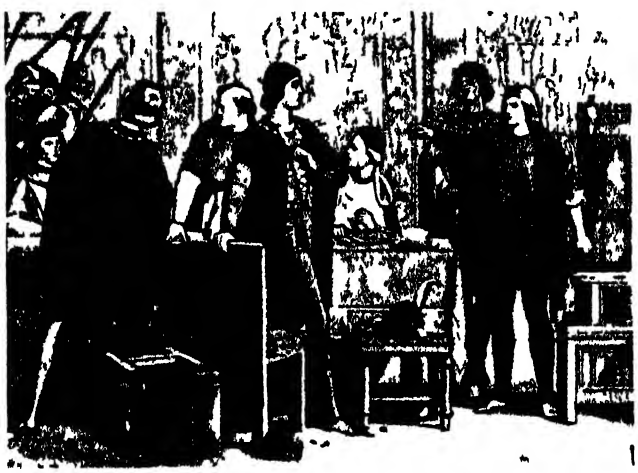
At any rate there seems reason to suppose that Richard was a very unpleasant person, and he was ruthless in removing from his path all who stood in his way. It was generally believed that he was responsible for Henry the Sixth's death, and that he had made up his mind that sooner or later he would himself mount the English throne.

Henry the Sixth and his son Edward were dead. Henry Tudor, descended from John of Gaunt and the Red Rose heir, was living in retirement in Brittany, and the only ones who stood in Richard's way after Edward the Fourth were his brother, the Duke of Clarence, and his nephews, the two little sons of the King.

We may well suppose that in view of his after history, Richard had something to do with inciting the King against the Duke of Clarence. At any rate, Clarence was charged with treason and magic, put in the Tower, and died mysteriously within ten days. Nobody ever knew the cause of his death, though it was freely stated that he was drowned in a butt of Malmsey wine. Richard at any rate gets the credit of this death.

Then the King passed away, and Richard at once set to work to seize power for himself and to pave the way to the throne. The little Prince of Wales was at Ludlow Castle at the time with his uncle Earl Rivers, the Queen's brother, and his tutor, and we get an interesting picture of his daily life.

He was roused early in the morning, and until he was dressed no one was allowed to enter his room except Earl Rivers, his chamberlain, and his uncle, Dr. Lionel Woodville, who was also his chaplain. Then, attended by these people, he entered the gallery pew of



"Traitor, I arrest thee," said Gloucester. "And I will not dine till I see thy head off"

the private chapel and heard Mass, and if the day happened to be a Festival of the Church, listened to a sermon from one of the two or three bishops in his household. Next he ate a light breakfast, and then did two hours' close study.

It was now half past ten, and the little Prince had dinner, the dishes being carried in by servants in livery. No one but his uncle was allowed to sit at table with him unless it was some one whom he particularly desired. While he had dinner stories were read aloud to him "such as it behoveth a young Prince to understand, of virtue, honour and knowledge, and of worshipful deeds and of nothing that shall move him to vice." Then after dinner there were two hours more of school and instruction and practice in various exercises. He attended Evensong, and the day closed with "such honest disports as were devised expressly for his recreation." At nine o'clock the curtain was drawn and he went to sleep.

No doubt the stories were very suitable, for the Prince's uncle was the same Earl Rivers who had translated the Dictes and Sayings of the Philosophers, which Caxton printed, the first printed book to be produced in England.

As soon as Edward the Fourth was dead, his widowed queen, Elizabeth Woodville, wrote at once to her brother telling him to bring up the young Prince, who was now Edward the Fifth, to London as soon as possible, taking care to levy a strong band of Welsh warriors to guard him.

Now the Queen had many enemies, chief among them being Richard, Duke of Gloucester, and Lord Hastings, the late King's chamberlain. Richard, however, pretended to be a friend not only of the Queen but of the little prince, and he proclaimed Edward the Fifth as king in York, where he was all powerful.

But Hastings, while fully determined that the little Edward should reign, was equally determined that all power should be taken from the Queen and her family. He was therefore very anxious that the Welsh force which she had ordered her brother to gather and bring to London should not come with the young King. He tauntingly demanded who this army was to fight. Surely not those who had supported the throne of York with their best blood? Surely not the King's gallant uncle, the Duke of Gloucester, who had proclaimed the new King so dutifully at York? Then, Hastings added, the valiant Welshmen must have been called out to support the Queen's kindred in power.

The Queen Mother felt inclined to countermand the order for a Welsh army to come to London, and when she received a very courteous letter from the

Duke of Gloucester, expressing loyalty to Edward the Fifth and profound respect to herself, she finally made up her mind and told her brother to bring the young King with no other guards than the lords and gentlemen who composed his court at Ludlow.

Directly this was known, news of it was sent by the Duke of Buckingham to the Duke of Gloucester at York, and that prince was urged to march at once with two thousand men to meet Buckingham at Northampton, who would arrive there with one thousand armed followers With these, declared the Duke of Gloucester, they would be able to secure mastery of the kingdom. Richard Crookback did as he was advised, and on the day that he and his friend joined forces at Northampton, Edward the Fifth and his party reached Stony Stratford twelve miles away

Utter Deception

When Lord Rivers heard that armed squadrons had been seen on the Northern road and that Gloucester and Buckingham had arrived with a formidable array, he decided to leave his little nephew, the King, at Stony Stratford, and go to Northampton to investigate It seems a mad thing to have done, but apparently he had no serious suspicion of the Duke of Gloucester's intentions. When he arrived Gloucester greeted him heartily, saying, "Welcome, good cousin out of Wales," and added some pleasant words about the happiness he felt at the peace and goodwill which now pervaded the country and the people generally.

Rivers was utterly deceived, and when he was invited to supper with Gloucester he went quite readily Gloucester made himself very affable and drank the health of Lord Rivers. Lord Rivers slept at an inn between two other inns, one of which was occupied by the Duke of Gloucester and the other by Buckingham.

As soon as he was asleep the two dukes obtained the keys of his inn, locked the gates and, appointing sentinels, forbade anyone to enter or leave. Then they sent out armed parties to occupy the high road from Northampton to Stony Stratford, afterwards setting out themselves, when they were met by Lord Hastings. Going to the young king who was about to start for London with his attendants, the treacherous dukes alighted, knelt before him, and greeted him with professions of loyal veneration, adding that they had hastened to meet him on his journey so that they might attend him and do dutiful service by the way. Then, rising from his knees, Buckingham gave the order in a loud voice, "Gentlemen and yeomen, keep your places and march forward"

The royal procession started once more for London, but scarcely was it outside the town of Stony Stratford when the dukes of Gloucester and Buckingham began to pick quarrels with the King's friends. They accused the King's half-brother, Lord Richard Gray, of conspiring with Lord Rivers to rule the King and realm, and at once arrested him, together with Sir Richard Haut, the Queen's brother-in-law, and Sir Thomas Vaughan, the King's guardian. The party was ordered back to Northampton, the King weeping and pleading for his half-brother.

The little Duke of York being taken from his mother in Westminster Abbey to join his young brother, King Edward V., in the Tower of London. From the painting by N. Gosse

An Ugly Awakening

Meanwhile, at Northampton, the servants of Lord Rivers when they began stirring in the morning, found that the inn was locked and all those within prisoners closely guarded. They woke their master and told him, but so completely deceived was he that he thought it was merely a joke or a mistake. By the time he was dressed, however, Gloucester and Buckingham had returned, and when Rivers coming into their presence exclaimed merrily, "Brother, is this how you serve me ?" he was met by stern looks and the words from Buckingham, "I arrest thee, traitor, for thy badness."

"Arrest !" said Rivers in amazement "Why, where is your commission ?"

In a moment Buckingham drew his sword, and all his party did the same. Rivers saw that opposition was useless, and he was forthwith put under a guard Then the conspirators appointed new attendants for the King, and proclaimed in the streets of Northampton that Richard, Duke of Gloucester, was appointed Lord Protector of his Majesty's person and realm It was a tragic experience for the boy king. All the friends and relations whom he loved had been made prisoners, and though there was a pretence of respecting his Majesty it was clear that he, too, was under restraint.

Lords Rivers and Gray were sent off to Gloucester's stronghold in Yorkshire, and the other prisoners were also placed in different gaols in the north. No time was lost in executing Lord Rivers, Lord Gray, and the other friends of the Queen who had been arrested

Seeking Sanctuary

Somebody must have written swiftly to tell the Queen what had happened, for that very evening she heard the news at Westminster Palace. How she must have wished she had never been so foolish as to countermand her order for a Welsh armed force to be brought to London Realising her danger, she at once took sanctuary in the abbot's residence at Westminster Abbey, taking with her her five young daughters and the King's little brother Richard, Duke of York, a child of nine, four years younger than the King. She did not fear the dukes of Gloucester and Buckingham so much as the Lord Chamberlain Hastings, who had always been her bitter enemy.

The Archbishop of York, a great and good man, took her a message from Hastings declaring that he was the devoted friend of her husband's children; and the prelate vouched for this, but the Queen could not believe it. "Ah, woe worth him !" she exclaimed passionately. "He thinks of naught but to destroy me and my kindred."

The Archbishop tried to comfort her, telling her that so long as she kept her second son in sanctuary Edward the Fifth would be safe, for if anything happened to the young king he would, himself, the next day come and crown young Richard of York King of England in Westminster Abbey. Of course,

Hastings was determined to deprive the Queen and her brothers of all power

Meanwhile, the royal procession reached London We are told that the loyalty of the Duke of Gloucester edified all beholders, for he rode bareheaded before the King, bowing, cap in hand, and with the other hand pointing him out, exclaiming from time to time in a loud voice to the crowds, "Behold your prince and sovereign"

Then the Privy Council was summoned, and Gloucester complained bitterly of the Queen's perversity in keeping little Richard with her in sanctuary The King was taken in state to the Tower of London where he lived in the Royal Apartments, and he was treated with all the outward homage of a sovereign A date was fixed for his coronation, and yet all this was mere outward form while plans were laid for Gloucester to seize the crown He was very anxious to carry with him all the important people in the realm particularly Hastings, and in a roundabout way inquiries were made as to whether Hastings would support Gloucester He was however completely devoted to the cause of Edward the Fifth and when Gloucester learnt this he decided on his destruction One day a Council was being held at the Tower and the Duke of Gloucester arrived in merry mood a little late

Sun and Storm

"I have played the sluggard this morning my lords and gentlemen, he said then turning to the Bishop of Ely, he said laughingly "My lord bishop, you have good strawberries in your garden at Holborn I pray you let us have a mess of them"

"Gladly, my lord, replied the bishop Would to God I had some better thing to pleasure you,' and he at once sent off his servant to Ely House in Holborn for the strawberries

Everybody was feeling very jolly and Gloucester went out of the Council Chamber for a short time When he returned his manner was quite different He knitted his brows, gnawed his under lip, and scowled till everybody became alarmed

"What are they worthy to be done to," he snapped out, "that compass the destruction of me, near as I am in blood to the King and Protector of his realm and royal person?"

The lords sat silent and astonished They had not the remotest idea what he meant At last Lord Hastings replied They are worthy of heinous punishment whosoever they be

An Amazing Scene in Council

Then Gloucester snarled out "Ye shall all see how that sorceress Elizabeth Woodville and that other witch her confederate Shore's wife, have by their witchcraft, wasted my body" Thereupon he pulled up his sleeve to the elbow and showed his left arm withered Of course everyone knew that from birth he had had a withered arm but no one now dared to say so

Jane Shore referred to as the Queen's confederate, was the particular friend of Hastings and he was nonplussed at the accusation, but he managed to stammer out Certainly they be worthy of heinous punishment if they have done this"

"If!" screamed the Protector "Batest thou me with ifs! I tell thee they have done so" Then raising his voice even more shrilly, he added,

"What if by thine own practices, William, I be brought to destruction And that I will make good on thy body traitor!"

Thereupon he thumped on the table, evidently a preconcerted signal, and at once there rushed into the Council Chamber armed men Traitor I arrest thee' said Gloucester

What me, my lord? exclaimed the astonished Hastings

"Yes thee, traitor,' replied Gloucester, and by St Paul I will not dine till I see thy head off"

The unfortunate chamberlain was rushed out of the room, made to place his head on a felled tree lying on the ground outside and at once his head was struck off the men at arms exclaiming jestingly that my Lord Protector was anxious for his dinner

Things were now coming rapidly to a head Richard determined to get the little Duke of York into his power by force if there were no other way but the Archbishop of Canterbury, wishing to avoid such an outrage as the dragging of a refugee from sanctuary went to the Queen himself to persuade her to release young Richard He declared that the King needed his brother as a playfellow

Troweth the Protector that the King doth need a playfellow?' asked the Queen Can none be found to play with the King but only his brother who hath no wish to play because of sickness?

The Queen Gives Way

For two days the arguments went on, and then the Queen gave way Each of the children be safe while they be asunder, notwithstanding I here deliver him, and his brother the King's life with him, and of ye I shall require them before God and man. Faithful ye be, I wot well, and power ye have if ye list to keep both safe But if ye think I fear too much, beware that ye fear too little

Then, handing her son over to the Archbishop, she said, "Farewell my own sweet son God send you good keeping Let me kiss you once more ere you go, for God knoweth when we shall ever kiss again" It was a pathetic scene The Queen wept and the little prince also cried as he was led away to his brother in the Tower

The two little princes imprisoned in the Tower of London From the well-known painting in the Louvre by Delaroche

An army of 9,000 foot soldiers had been brought from the North to London and without further pretence Richard was formally proclaimed King, as Richard the Third. The little Edward in the Tower of London must have heard the fanfare of trumpets as the heralds proclaimed his uncle's usurpation.

Edward the Fourth had died on April 9th, 1483, and Richard's accession is reckoned from June 26th, so that the poor little boy king reigned only eleven weeks, the saddest reign of any rightful English sovereign.

The two little princes were living closely watched in the Wakefield Tower at the Tower of London, and for a time were well treated, but soon the few persons who waited on them were sent away, and then they were closely imprisoned and one rough man, known as Black Will, alone attended them, though four others kept rigorous guard to see there was no escape.

A Night's Work

Richard was crowned, and then there started a splendid progress through the country. As long as the little princes lived he felt that his crown was insecure, and he therefore determined that they should be put out of the way.

He wrote to Sir Robert Brakenbury, Lieutenant of the Tower of London, telling him to deliver up the Tower with its keys for one night into the hands of Sir James Tyrrell. Selecting five followers, including two ruffians, Miles Forrest and John Dighton, Tyrrell set off at once for London.

On arriving at the Tower the assassins lost no time. Taking Forrest and Dighton with him, Sir James Tyrrell went to the bedchamber of the children. It was midnight, and they were fast asleep. While Tyrrell waited outside, the other ruffians went in and without ado proceeded to smother the boys.

Sir Thomas More, who wrote not very many years after the event, tells the story: "All others being removed from the Tower, Miles Forrest and John Dighton, about midnight, came into their chamber, and suddenly wrapped them up amongst the bed-clothes, keeping down by force the feather bed and pillows hard upon their mouths. Within a while they smothered and stifled them, and their breaths failing them gave up to God their innocent souls into the joys of Heaven, leaving to their tormentors their bodies dead in bed. After which the wretches laid them out upon the bed and fetched Sir James Tyrrell to see them. And when he was satisfied of their deaths, he caused the murderers to bury them at the stair-foot metely deep in the ground under a great heap of stones."

Shakespeare, in his play of King Richard the Third, very aptly describes this as:

> The most arch deed of piteous massacre,
> That ever yet this land was guilty of.

News was at once taken to Richard

Miles Forrest and John Dighton, about midnight, came into the chamber and wrapped the princes up amongst the bed-clothes. From the painting by Hildebrandt

and his only criticism was that his young nephews had not been buried by a priest in consecrated ground. He ordered this to be done. The order was carried out by Sir Robert Brakenbury's chaplain, but he died a day or two later and the secret of the new burial place died with him. This was very important in years to come, when impostors rose up and claimed to be the missing Duke of York. Great search was made, but the burial place could not be found.

In 1674, however, when an open stone staircase outside the White Tower leading up to a chapel was being repaired, some workmen digging at the foot found buried in the earth a great chest. It was opened, and inside were the mouldering remains of two boys. They were evidently those of Edward the Fifth and Richard, Duke of York, and Charles the Second ordered the bones to be collected, enclosed in a marble urn, and deposited in the royal vault at the upper end of the north aisle of Henry the Seventh's Chapel in Westminster Abbey, where a white marble tablet sacred to their memory is fixed to the wall, recording their mournful story in a Latin inscription:

"Here lie the relics of Edward the Fifth, King of England, and Richard, Duke of York, who being found in the Tower and there stifled with pillows, were privately and meanly buried by order of their perfidious uncle Richard the Usurper."

Richard Crookback gained little from his horrible treachery to friend and foe alike. No one trusted him, and he soon came to a bad end, being slain at the battle of Bosworth Field, when fighting for his crown.

The story is told in graphic and dramatic fashion by Shakespeare in his play "King Richard the Third." We see relentless fate overtaking the treacherous usurper, and on the eve of the battle the spirits of those whom he has slain rising up one after another to accuse him.

At the same time Henry of Richmond in his tent utters that magnificent prayer which is one of the finest passages in all Shakespeare:

> O! thou, whose captain I account myself,
> Look on my forces with a gracious eye;
> Put in their hands thy bruising irons of wrath,
> That they may crush down with a heavy fall
> The usurping helmets of our adversaries!
> Make us thy ministers of chastisement,
> That we may praise thee in thy victory!
> To thee I do commend my watchful soul,
> Ere I let fall the windows of mine eyes:
> Sleeping and waking, O! defend me still!

The battle takes place, and Richard, eager to join in single combat with his hated rival, slays warrior after warrior, but never the right man. At last he declares:

> I think there be six Richmonds in the field:
> Five have I slain to-day instead of him.

But in the end he is slain, and Richmond lives to become King Henry VII, and the play ends with his prayer:

> O! now, let Richmond and Elizabeth,
> The true succeeders of each royal house,
> By God's fair ordinance conjoin together;
> And let their heirs—God, if thy will be so,—
> Enrich the time to come with smooth-fac'd peace,
> With smiling plenty, and fair prosperous days!

It was as true of Richard as of the little nephew whom he killed that: "So hard is height; so cruel is a crown."

WONDERS of LAND & WATER

THE MYSTERY OF THE MUD IN THE STREETS

Mud is a great nuisance. When the weather is rainy the streets become very muddy and we cannot walk without being splashed. Motor-cars and other vehicles, too, become covered with mud, and a great deal of money has to be spent in cleaning these down and removing the mud from the streets. What is it that makes the mud? The answer provides a very interesting story, which is told in these pages

WHERE does all the mud in the roads and streets of our cities come from? We see the roadways and the pavements on a dry day clean and white with little dust lying about, and as we know, the streets are cleaned every day, the rubbish being swept up and collected. Then it begins to rain, and as the water comes down it is not long before the roadways and the pavements are covered with mud.

What is the explanation of this? What causes the mud? According to the dictionary mud is moist and soft earth or earthy matter, but where does the solid matter come from that, mixed with the rain, produces the mud we see in the streets? Some people have the idea that it is the dust worn off the surface of the roads and pavements by the traffic, and it is true that a certain amount of dust may be caused in this way, but the amount is so small that it cannot possibly account for the sudden appearance of mud almost directly it begins to rain.

Mud looks very unattractive and proves a great nuisance as the traffic throws it up on our clothes or it splashes our stockings and trousers as we walk, but really the mud represents wealth and it has been well said that the muddy streets are paved with gold. Nearly all the solid matter that forms the mud falls from the sky, and before it comes down it must go up. Let us remember how the rain is formed.

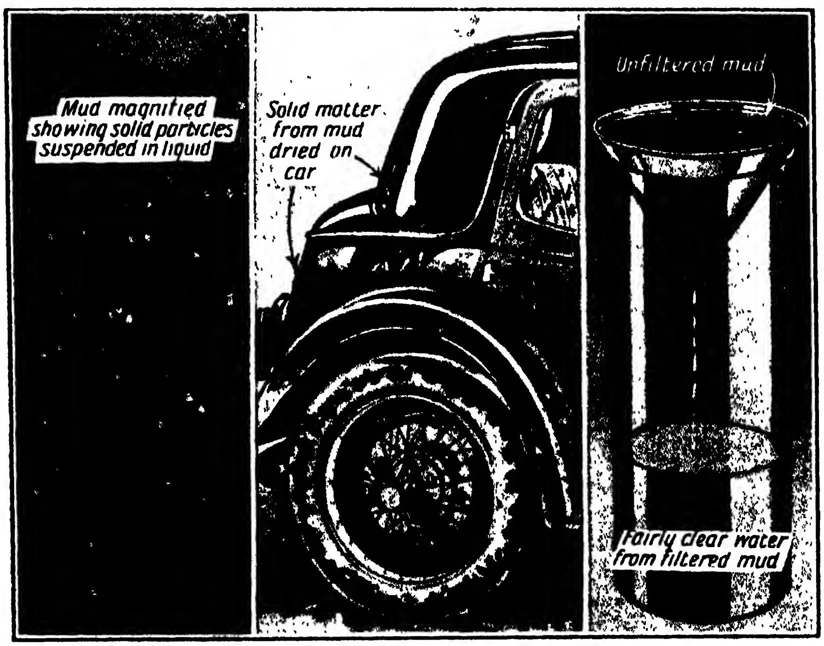
There is much acqueous or water vapour in the air, the quantity varying according to the temperature of the air. The warmer the atmosphere the more invisible water vapour it will hold, but as soon as the air becomes cooler some of this water vapour condenses and becomes visible as fog or cloud. When it is at the Earth's surface we call it fog; when it is high up in the sky we call it clouds.

Now, before the water can condense into drops it must have something to condense round. Every drop of moisture in a cloud or in the fog, and every raindrop, has a particle of dust inside, and upon this the moisture has condensed. When, therefore, the cloud becomes so heavy that it can no longer remain suspended in the air but falls as rain, each raindrop brings down with it its little particle of dust or solid matter.

It is these particles, mixed with the particles lying on the ground, which have been worn off the surface of the roads and pavements by wheels and horses' hoofs and pedestrians' feet, that provide the solid matter for the mud. It has been estimated that the amount of mud which falls on London alone in the course of a year amounts to something like 76,000 tons. This is either washed down our drains or has to be swept up and removed at great expense, yet the value of the material in this mud is estimated to be worth hundreds of thousands of pounds.

How did the particles of solid matter get into the air? Well, they went up as smoke which is made up of fragments of unburnt fuel. When we see the smoke rising from the chimneys on houses and factories and disappearing in the air we are really watching the mud go up and, later on when the rain falls, we can see the mud come down.

Of course, it is a very ridiculous thing to waste wealth in this way. Black smoke passing out of a chimney is wealth going to waste. If we were wise we should not allow this waste, but should burn our coal in such a form of stove that there could be no waste. The waste is double, for first of all we lose money when the smoke escapes from the chimney, and we have to spend more money in getting rid of the mud when it falls to the earth once more.



Mud is really solid matter suspended in water. We can see this as in the first picture if we examine mud through a microscope. The fact is also proved when the mud dries on our car or clothes, as in the second picture. A patch of solid matter is left where every splash fell. We can still further prove that mud is solid matter in suspension by filtering some mud through blotting-paper. The water that passes through will be fairly clear, and the solid matter will be left behind in the blotting paper as shown in the right-hand picture

A parliamentary committee which sat some time ago to consider means of abating smoke in our towns and cities reported that about 3,000,000 tons of valuable materials were poured into our atmosphere every year through the chimneys of houses and factories. Five-sixths of it went up from domestic fireplaces and chimneys, while the remaining sixth was provided by the furnaces of factories, railway engines, and offices.

This unburnt fuel is not merely wasteful, it is harmful to health. If it is in the atmosphere we must breathe it and it is not good to breathe the

TONS OF MUD GOING UP AND COMING DOWN

The mud which we find in our streets, and which is such a nuisance is really wealth in the wrong place Some people think that the whole of the solid matter of the mud which we find on our clothes when the moisture has evaporated is due to the pounding into dust of the ground by the action of road transport wheels and the shoes of pedestrians This, however, is not the case Most of the solid matter of the mud has gone up as smoke from the chimneys of factories and houses It really consists of fragments of unburnt fuel and so we get a double waste the waste of fuel which passes away unconsumed, and the waste of cleaning our streets and garments and vehicles of this unconsumed fuel when after being mixed with rain, it has became mud Of course, not all of the particles of unburnt fuel belched from the chimneys of grates and furnaces consuming crude coal return to the ground as mud A large part of the soot from chimneys, particularly in industrial areas, is responsible for fog In Great Britain, the prevailing winds are moisture laden from the Atlantic and in winter they meet cooler currents over the land and mingle with the dust and soot floating above cities The fog particles in the atmosphere then become coated with soot, which makes it difficult for them to evaporate consequently they gather together and form a blanket shutting out the sun

In the country we can of course collect rain water that falls on the roof of the house, and save it in a butt for use in washing our hands and faces But the rain that falls in towns and cities would be far too unclean for any such purpose Not only would it carry into the water butt a great deal of grime from the roof and pipes, but the rain itself, as it falls, brings down with it countless particles of soot and dust gathered from the air It is these particles that have most to do with forming the mud in the streets

materials that are found in smoke. Then it hangs like a pall over our towns and cities and shuts off many of the Sun's rays which bring both wealth and health. Plants suffer as a result, and we realise this when our town gardens do not flourish; but we must remember that what is harmful to plants is also harmful to human beings.

Experts who gave evidence before the parliamentary committee declared that the solid matter going off in smoke represented an annual waste of £6 000 000. But that was merely the cost of the solid matter which escaped. In addition, owing to the wasteful method of burning coal that is in force to-day, many valuable gases and volatile oils are also lost. If this waste were to be remedied we should not only be richer as a nation, but we should also be healthier, and our cities and towns would be cleaner. We should have rainy days with very little mud lying about in the streets.

About 40 000 000 tons of coal are burnt by the domestic fires of Great Britain every year, but of these it has been estimated that from one to two thirds of the heat producing elements are wasted. The loss therefore in the burning of domestic coal alone must amount to something like £40 000 000 a year.

The mud in our streets and roads may seem a mystery, but there is really no mystery about it. It goes up from our chimneys and then is washed down with the rain.

Of course, the mud in country lanes and fields and roads is formed in a different way. Here the rain mixes with the clay or other earth and forms the mud directly on the ground.

WHERE THE WATER OF THE SPRING COMES FROM

When we are in the country we always like to find a spring and to drink the cool water that flows from it. Apart from its coolness, the spring water seems to taste so much better than the ordinary drinking water which we obtain from the tap in the house. Why is this?

Well, before we can answer the question we must understand how springs are formed and where the spring water comes from. Of course, like all fresh water that is found on the Earth, whether it be in a lake, a river or a brook, the spring water comes in the first place from the clouds.

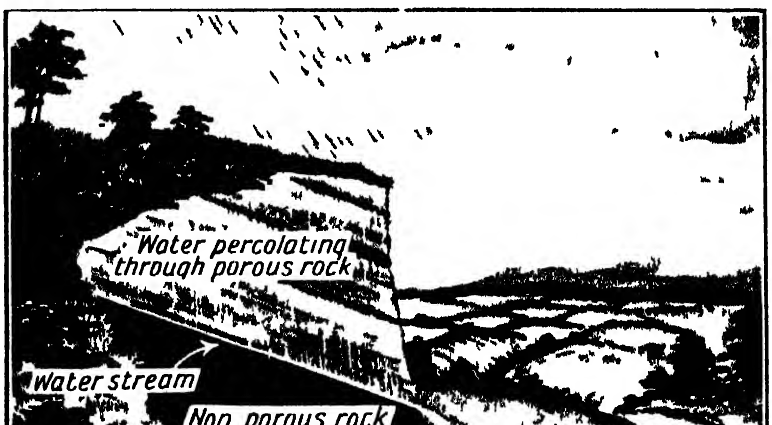
Water is evaporated from the sea by the heat of the Sun; it rises as an invisible vapour, the wind carries it along, and sooner or later it meets a cold layer of air which condenses it into drops of water, and when these become too big and heavy to be sustained they fall in the form of rain.

What happens to the rain? Well, some of it runs away on the surface of the Earth, down slopes and hills, till it reaches a stream or river, and then it passes down to the sea. But other rain sinks through the soil till at last it reaches a layer of earth such as clay which is impervious to water, and there it remains unless the bed of clay slopes, when the water makes its way down the slope as an underground stream or river.

Such subterranean streams are found in all parts of the world, and when a well is sunk and water is obtained it means that the well has reached an underground lake or river of the kind described.

Sooner or later the underground stream, as it makes its way through the earth, unless it is very deep down, reaches the side of a hill or the face of a cliff where in the course of ages the earth or rock has been worn away by the weather or some other agency. It then gushes out of the hillside as a spring, and it is at such a place that we see the spring and are able to obtain the water for drinking.

The spring water is cold because it has been for a long time underground away from the heat of the Sun and atmosphere, and it tastes pleasant because it is hard; that is, it has a good deal of mineral matter dissolved in it. Hard water is always more pleasant to taste than soft water, and water which has been distilled and has practically no mineral matter in it is exceedingly insipid. We should certainly not like to drink it often. The spring water in its course underground has dissolved much of the mineral matter it passed through.



This picture explains how the spring that pours or trickles from a hillside or cliff is formed. Rain falling on the ground percolates through the earth till it reaches a non-porous layer through which it cannot pass, and then it begins to run down the slope till it finds an outlet which we call a spring.

The depth at which the underground stream flows depends of course upon the thickness of porous earth through which the rain has been able to percolate. If the impervious bed is far down, then the underground stream will be deep. Sometimes these streams suddenly burst into a coal mine, flooding the mine and unfortunately drowning the miners. At other times in the course of mining an underground stream is tapped by the miners as they dig, and then, too, there is a danger of flooding.

Underground water, indeed, is one of the great hindrances to quarrying and mining. Many a valuable mine has had to be abandoned owing to the impossibility of getting rid of the water from underground streams and springs. Miners speak of such a pit as being drowned. The powerful pumping engines which are seen everywhere in coal mining districts are for the purpose of pumping out the water which gathers underground and making them safe for the miners.

We speak of rock and earth through which water can percolate as porous, and that which will not allow water to pass through it as non-porous or impervious.

In times of drought springs and wells and underground streams that are near the surface often run dry, while those that are more deep-seated continue to have supplies of water. The reason is that the deeper streams are less dependent upon the rainfall of a particular district. They draw their supplies from a wider area, large parts of which may be outside the dry region, and are thus likely to receive continued supplies

THE GIANT'S ROADWAY BUILT BY FIRE

One of the most remarkable rock formations in the British Isles is to be seen at the Giant s Causeway, in Northern Ireland This was once molten lava like that thrown out by Etna, but as it cooled it shrank and cracks formed which divided it up into six sided columns fitting closely together as though they were part of a building erected by man The place was given its name because a legend said it was the beginning of a roadway constructed by giants across the sea to Scotland The other end of the formation is at Fingal's Cave in the Isle of Staffa This photograph gives a good idea of the strange appearance of the Giant s Causeway The rock is called basalt

The mass of basalt of which the Giant s Causeway is part, is from 300 to 500 feet thick, and covers almost the whole of County Antrim and the eastern part of Londonderry Some of the columns are 200 feet in height, but in many cases only the tops of the columns are visible as shown here and then the appearance is that of an irregular mosaic pavement Most of the columns are six-sided, but there are also examples with five seven eight and nine sides Altogether, at the Giant's Causeway, there are the tops of 40 000 closely fitting columns in view The curious column form of the rock is due to shrinkage during the cooling of the lava

REMARKABLE FACTS ABOUT THE AIR

The air which we breathe and which is all round us has many physical properties. It can be compressed when it is squeezed together, and when the pressure is removed it expands. The great weight of the atmosphere above us exerts pressure, not only downwards, but in all directions, and there are many striking experiments which prove this. If it were not for this pressure a syringe would not work. In these pages we read many important and interesting facts about the properties of air

ALTHOUGH we cannot see the atmosphere we know that it is a real substance. The experiments on page 22 have proved this, and we know that the barometer and the pump owe their working to the pressure of the atmosphere.

We realise how great is the pressure which the air can exert when we try to walk in a gale. The wind is so strong that it takes a great deal of exertion to make headway against it, and sometimes it is powerful enough to blow over not merely people but motor-cars and trams. That is why it is always dangerous to walk near the edge of a cliff when anything like a strong wind is blowing. It may push us over.

In erecting tall buildings the architect always has to take into consideration the pressure of the wind that may be exerted against the walls, and even in erecting poles for carrying electric cables across country, wind pressure must be taken into account.

Danger in the Wind

One would hardly think that the pressure of the wind against a thing so small in diameter as an electric wire would need to be considered. We know, however, that from time to time a great gale sweeps over the country and thousands of miles of telegraph wires are blown down, carrying the wooden posts with them.

In normal times we do not feel the pressure of the atmosphere at all, and yet it is equal to nearly fifteen pounds on every square inch of our body, and the total pressure on a full-grown man amounts to ten or twelve tons.

Put a weight of ten or twelve tons on a man and he would be crushed to death. Why is it that the pressure of the atmosphere is not fatal? It is not due to the fact that air is invisible nor that it is so much drawn out that the column of air reaching above us is about 300 miles high, although half the volume of air surrounding the earth is packed into a region only 3½ miles above the earth.

The reason we do not feel the tremendous pressure of the atmosphere upon our bodies is that the pressure outside is met by an equal pressure inside. Our bodies are full of air, but air, being a fluid, presses equally in all directions so that the pressure inside balances the pressure outside.

If the great pressure of the air on the outside of our bodies is removed suddenly, so that we cannot adjust ourselves to the change, then troublesome and sometimes serious consequences result. If we were placed for example in a chamber connected with an air pump and a great deal of the air were extracted rapidly from the chamber, apart from not having enough air to breathe we should find that our bodies could not adapt themselves to the pressure change quickly enough, and probably we should start bleeding at the nose and mouth. The pressure of the air inside the body being greater than that outside would push the blood out.

We are so used to the pressure of nearly fifteen pounds to the square inch on our bodies that those who climb very high mountains like Everest, find difficulties when they get far up, owing to the reduction of pressure. Of course there are the difficulties that come from getting insufficient oxygen for the lungs, but apart from this there is the fact that the walls of our arteries do not stretch so rapidly as those of our veins, and so when the outside pressure of the air is reduced there is an increase in the volume of blood in the veins and the balance of blood between the arteries and the veins is upset.

This great pressure exerted by the atmosphere seems very wonderful when we come to think of it. For instance we look at a kitchen table, which measures about four feet by four feet, that is, has an area of sixteen square feet. The pressure of the air on this small table is about fifteen tons, or in other words it is about the same as if we piled on the table 150 ordinary sacks of coal, each weighing two hundredweights.

Of course, it is the same with the table as with our bodies—the pressure underneath is equal to the pressure on top, and so things are equalised. This is true even if there is a drawer in the table, for there is air in the drawer just as there is air outside.

On the left, the air having been extracted from the jar, the pressure of the atmosphere outside stretches and breaks the skin over the top of the jar. On the right the boy is blowing into the balloon, and the pressure inside becomes so great that at last the balloon bursts outwards

The Power of Air

There are many experiments which we can perform to show how real is the pressure of the air. If we take a jar which has an air-tight connection with an air pump, and tie over the top a piece of rubber skin, seeing that the whole jar is airtight, and then exhaust the air from the inside, we shall find that the pressure of the atmosphere on the skin depresses it, and if enough air is exhausted from the jar the outside air will probably break the skin.

The reason, of course, is that by extracting the air from the jar the outside pressure upon the skin is very much greater than that inside. The opposite effect can be obtained by taking an ordinary toy balloon and blowing it up bigger and bigger. By constantly blowing more air into the balloon we increase the inside pressure and at last the skin gets so stretched that it cannot resist this pressure, and it bursts outwards.

There is another interesting experiment with an air pump which we can carry out. We take an ordinary rubber balloon and blow into it a very small quantity of air, only sufficient to blow

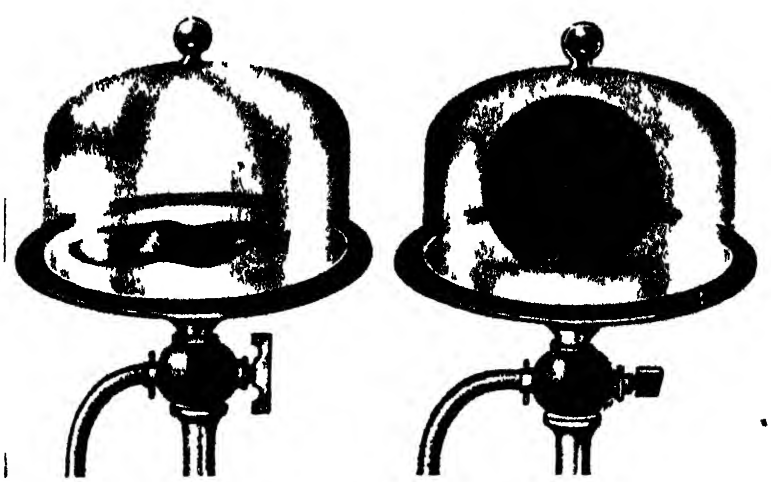
it out a little. We fasten up the neck tightly so that the air cannot get out. Then we lay it on the table or hold it in our hand, and it remains in the same condition because the pressure inside is balanced by the pressure of the outside air.

Now let us place the same balloon under the receiver of an air-pump and begin working the pump, drawing the air out from the chamber in which the balloon rests. As we draw the air out the balloon begins to swell and continues till it is as big as if we had blown it out properly in the first place.

Why is this? Well, gas is elastic and capable of expanding; that is, the molecules of which it is made up can, when the outside pressure is removed, get farther and farther apart. In doing this they push out the balloon so that it has the same appearance as if it were blown out in the ordinary way. When we let the air into the receiver again the balloon immediately collapses.

Many years ago a distinguished German scientist, Otto von Guericke, performed a striking experiment in the presence of the German Emperor which showed how great the pressure of the atmosphere was.

It was in 1651, and there was a notable gathering of courtiers and others to see the experiment carried out. Von Guericke had already done the experiment before, and when news of it reached the emperor he wished to see it done, so unbelievable did it seem to him. We must remember that at that time the pressure which the atmosphere exerts was not generally known.



A very little air has been blown into the balloon shown on the left, which is placed in an air pump receiver. The air, however, has not yet been extracted from the receiver. When it is extracted the outside pressure on the balloon is removed and the little air which is inside it expands till the balloon looks as if it were fully blown up.

A Vacuum in the Sphere

Von Guericke made a sphere of metal, or rather of copper, divided into two halves. These were placed together, and in order that the union might be airtight he put between the two halves a ring of leather saturated in wax and turpentine. Then Von Guericke, by means of his pump, extracted the air from the inside of the hole, making the space as near a vacuum as is possible. He had himself invented the air-pump not long before.

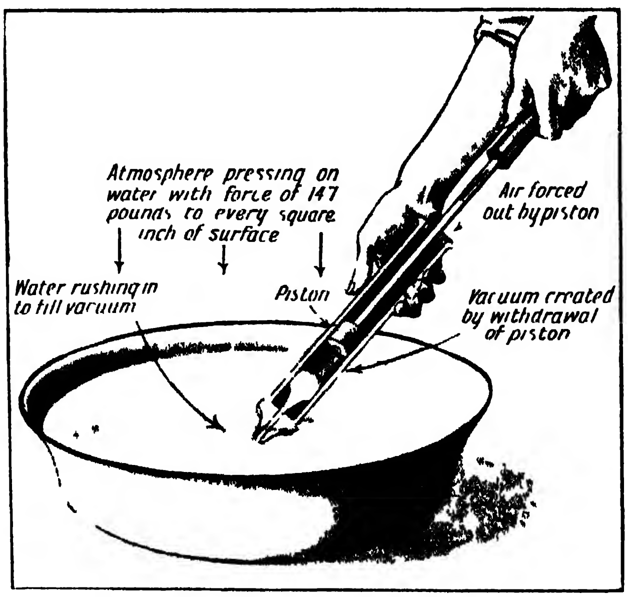
When all the air was extracted from the sphere a tap was turned so that no more air could enter from outside. The two halves of the sphere were not fastened in any way, but the outside pressure of the atmosphere kept them together. The sphere was a large one, and so the area of the outside was many square inches. The pressure therefore upon each half of the sphere was very great indeed.

Now came Von Guericke's spectacular experiment. He harnessed to each half of the sphere eight powerful horses, and then driving these in opposite directions it was only with difficulty that they could drag the two halves of the sphere apart. Yet when air was admitted to the sphere a man could separate the two sections quite easily.

This was the first great proof of the pressure of the atmosphere, and yet there were still sceptics who did not believe in it. Von Guericke therefore performed another experiment. He took a cylinder which had a tightly fitting piston and suspended the piston by a strong rope passing over a wheel. To the end of this big rope he fastened twenty smaller ropes, each of which was held by a very strong man.

The piston was pulled up to the top of the cylinder and held there by the twenty men. Then Von Guericke extracted the air from the cylinder by a very ingenious device. There was a hole in the bottom of the cylinder, and into this he placed the nozzle of a large globe from which air had been extracted by means of his air-pump.

As soon as the scientist turned a tap air rushed from the cylinder into the empty globe, driven in by the pressure of the outside atmosphere on the piston. The piston descended so rapidly by this pressure of the air on its outside that the twenty powerful men, although exerting all their strength, were quite unable to hold it up.



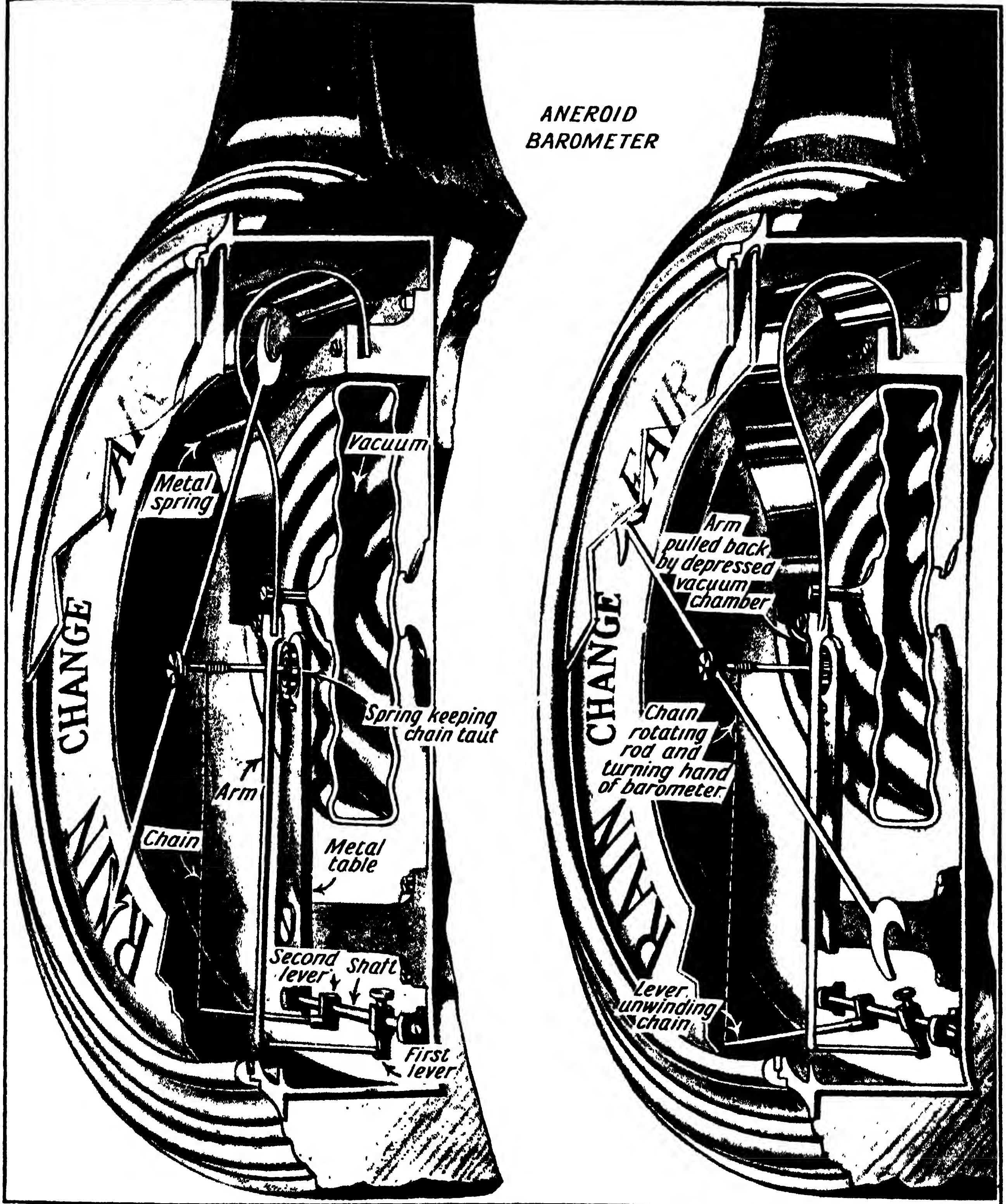
This picture shows how a syringe works. As the piston is drawn up a vacuum is created between the nozzle and the piston, and the pressure of the air on the water in the basin forces it up through the opening into the barrel of the syringe.

How a Syringe Works

When we use a syringe, either one of the small glass syringes sold in chemists' shops or a large garden syringe, we draw up the handle with the piston at the end, and the water or other fluid rushes up into the syringe. We call this sucking up the liquid, but of course what really happens is this. When we put the nozzle of the syringe in the fluid and then draw up the piston, a vacuum is left between the nozzle and the piston, but as the old writers used to say, "Nature abhors a vacuum."

The air is pressing on the surface of the liquid in the bowl or other vessel at the rate of nearly fifteen pounds on every square inch of surface. As therefore the vacuum is formed, the pressure of the air on the water pushes it up the nozzle of the syringe to fill the vacant space. Of course it is essential that the piston be air-tight.

HOW AN ANEROID BAROMETER WORKS



Here is an aneroid barometer which can be placed in any position and need not be kept upright, for it has no mercury. That is why it is called Aneroid, the word coming from the Greek and meaning " not wet." A metal box from which all air has been drawn is prevented from collapsing by a strong metal spring. On this spring is a long arm or rod connected by a pivot with another rod which moves the first lever shown in the picture This lever, fixed on a shaft, causes a second lever and rod to make the same movement. To this latter rod is attached a fine chain which winds round the rod on which the indicating hand of the barometer is fixed. A spring keeps the chain taut, and the rod with the hands and spring is held in position by a strong metal table fixed to the case of the barometer. As the air pressure on the vacuum box varies, its surface moves in and out, operating the levers and turning the hand. In the first of these pictures the pressure is low and in the right-hand picture the pressure is high. For simplicity's sake the words, Rain, Change, and Fair, in the drawing of the ba-ometer have been brought round to the visible side of the dial

SPRING-HEELED JACKS OF AUSTRALIA

There are over fifty different kinds of kangaroos, large and small, and they are all great jumpers. Although they are by nature furnished with four legs they use only the two hind ones as organs of progression. The kangaroo springs from the ground in an erect position, and propelled by its powerful hind legs and balanced by its tail, with its forearms held towards the chest, it sets off hopping at an astonishing pace, clearing very often thirty feet at each spring. It is also a good jumper, and when pursued can easily clear low fences

HOPPING A WAY THROUGH LIFE

Australia has some very curious animals. There are mammals that lay eggs, like the platypus and echidna, and there are animals that have pockets into which they tuck their young, like the kangaroos, the wallabies and the opossums. The kangaroo is a very interesting animal, as we can see from the account of it given here. Some of the smaller kangaroos known as rock wallabies, which live in Central Australia, leap and climb about the rocks with great agility, and when they are pursued or danger threatens flee to deep holes in which they hide

THERE are two things about the kangaroos which everyone knows In the first place, they have a pouch or pocket in which they carry their children, and in the second place they move forward, not by walking or running but by jumping or hopping They are certainly very queer looking animals They have huge hind legs and tiny forelegs while their tails are so long and stout that they use them as supports and rest upon them much as we do upon a stool or shooting stick

Why do kangaroos have a pocket? Well they are unlike other mammals in this that they produce their young in a very imperfect and helpless condition In fact it has been said that when kangaroos are born they are little more than animated lumps and they have to be carried about for quite a long time If the mothers had not got a pocket for the purpose it is doubtful if many young kangaroos would survive

Many Kinds of Kangaroos

Of course there are many kinds of kangaroos Some are large and some small some have enormous hind legs and some have quite slender ones

All the members of the kangaroo family are vegetarians and except for some of the smaller varieties found in Papua or New Guinea they are all confined to Australia and Tasmania The wallabies are really kangaroos

When Captain Cook visited Australia in 1770 and his crew landed to obtain food, they were astonished to see animals of a large size which sat upright using their big tails as a prop and they were still more astonished, when these animals hurried off to see them move, not at a gallop but in a series of enormous jumps When they told their story to their shipmates the excitement was great

Soon afterwards a kangaroo was shot It was the first of its family to be examined and studied by Europeans although there were some rumours of this strange creature sixty years earlier

Both the names "kangaroo" and "wallaby" are Australian native names There are over fifty different species and the larger kinds are as tall as a man The smallest however are only as big as a rabbit The best known of all the kangaroos is the great grey kangaroo which was known to the early colonists of Australia as "the old man" probably because it sat up straight and "the forester"

The only time the kangaroo is ever seen moving on four feet is very occasionally when it is browsing on the grass and other herbage Its movement however is very slow and awkward The upright position is as normal with kangaroos as with mankind and the structure of their skeleton is adapted to this position

When it goes forward the kangaroo springs from the ground in an upright position holds the short forelegs close against its chest like a human runner and then bounds lightly and rapidly forward propelled by its powerful hind legs It jumps carefully over obstacles that lie in its path such as fallen trees and fences and it will cover thirty feet at one jump As it leaps away the thump of the tail on the ground at each descent can be distinctly heard

A mother kangaroo with her young one tucked away in her pocket Even when the young one is travelling by its mother's side, if danger threatens the female kangaroo can pick up her child while running at full speed and thrust it into her pouch with its face looking out But if hard pressed she throws away the young one to save herself

Love of Company

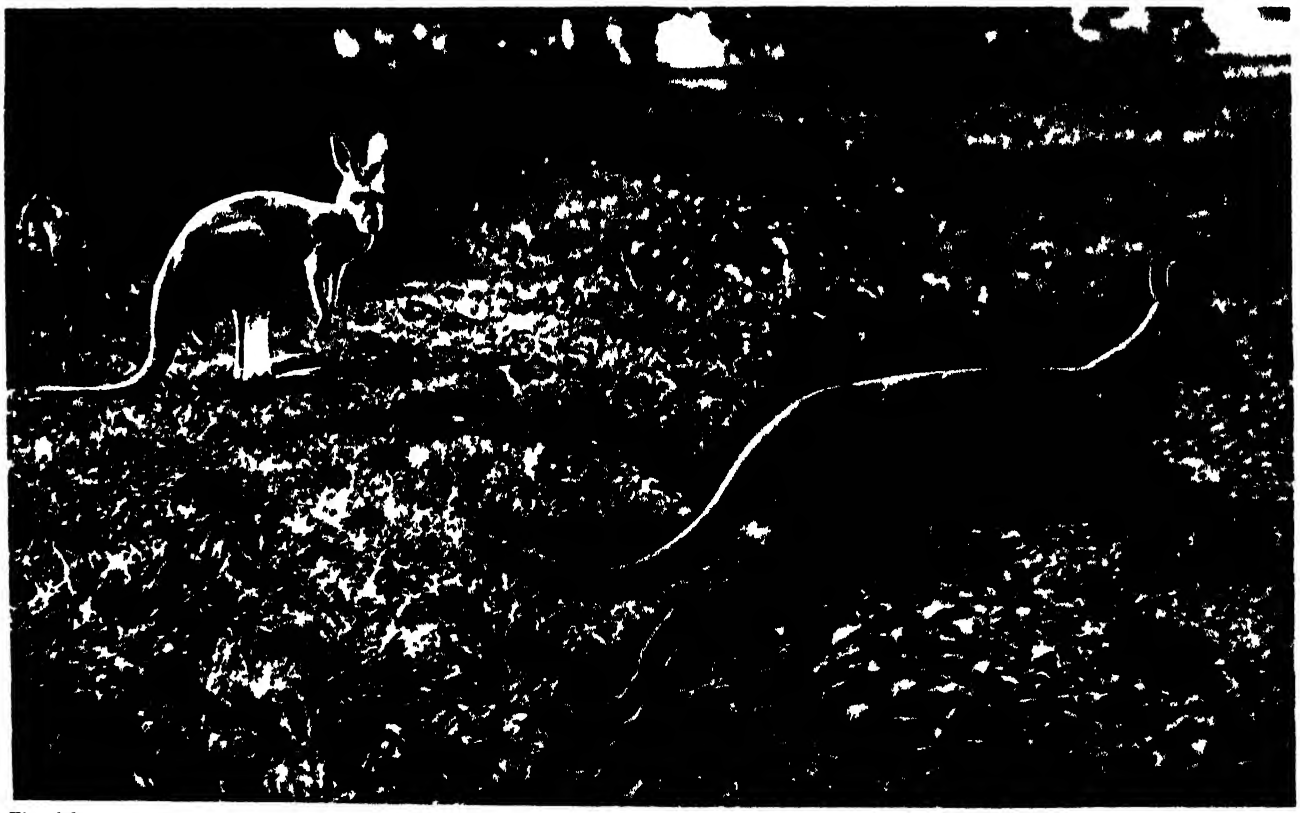
It is rather a timid and shy animal and although its hearing and scent are acute its sight is not good

Kangaroos love one another's company and in the old days, when there were more of them droves of as many as 150 were seen together Now the droves are much smaller They usually do their feeding early in the morning or soon after twilight resting during the day in damp gullies They are as playful as kittens, and it is a very interesting sight to see them sporting with one another When they go about in droves there is usually a leader and the others follow implicitly At the pairing season the males fight fiercely

They are good swimmers and one has been known, when pursued, to take to the sea and swim for two miles against a strong current They are

A KANGAROO ENJOYS A BOXING MATCH

It is a fact that the kangaroo one of the most remarkable of animals can be trained to box excellently In these pictures we see a boxing kangaroo giving an exhibition in London Sometimes he can knock out his trainer but as can be seen in the pictures, the kangaroo does not keep strictly to the rules of boxing for in the first photograph he is using his feet as well as his hands It is a good job the animal is merely playing for in the powerful hind claw of each large leg the kangaroo has a very formidable weapon of defence It has been seen to kick a dog that was attacking it and rip it open as a wild boar might with its tusk



The different species of kangaroo vary much in size Male specimens of the great grey kangaroo sometimes weigh over two hundredweights and measure over five feet from the tip of the nose to the root of the tail while the tail itself measures another four to four-and-a-half feet The smaller kangaroos are called wallabies or brush kangaroos When the kangaroo rests its usual position is to have the whole of each foot on the ground the knee joint forming the summit of a solid support from which the whole body is suspended, as if on pivots This can be seen in the left hand animal in this picture The kangaroo can, however, raise itself up on the tips of its toes and its tail the two hind legs and the tail forming a kind of tripod In this position it is able to take a wide view of the neighbourhood and look out for enemies The long tail is a help to the kangaroo in its movement forward, and the measured thumps of it on the ground as the animal moves along can often be heard long before the kangaroo itself appears in sight

a pest to the farmer, for at night they enter his fields and nibble off the young blades of wheat and other crops.

In the Pleistocene Age there were kangaroos far bigger than those which exist to-day. The remains of one have been found whose skull was more then three feet long. But some living kangaroos weigh more than two hundredweights.

The kangaroo is a harmless and inoffensive animal when let alone, but it has a powerful weapon in the massive hind claw, and with this it can rip up a dog in the same way as does the tusk of a boar. If pursued by dogs a large kangaroo will sometimes pick up one of its enemies in its forepaws bear fashion, and try to bite it. If kangaroos catch a dog in their claws when they are in the water they invariably try to drown it. Some colonists have declared that they will even seize a dog and carry it to a water hole for this purpose, but that is probably only a traveller's tale.

Thousands of the skins of smaller kangaroos and wallabies are sent to London every year. The great kangaroo can be easily taught to box like a man, and seems thoroughly to enjoy the sport. Boxing kangaroos are exhibited from time to time in England and other European countries.

The small rat kangaroo of New Guinea, which is really about the size of a large rat, has a very flexible tail, by means of which it carries bunches of grass for its nest, and it is an amusing sight to see it leaping forward with its tail loaded in this way.

EXPERIMENTS ILLUSTRATING THE SENSE OF TOUCH

OUR sense of touch is of great importance to us, and to a blind man it is the principal means by which he gets to know the shape and nature of things.

Beneath our skins there lie little oval bodies known as touch corpuscles, with a nerve fibre winding round each and ending in it. The corpuscles are so formed that the nerve inside can be compressed by a touch on the skin, and

Guessing which finger is touched

in this way it is stimulated and sends a message to the brain.

The skin is not equally sensitive in all parts of the body, and there are a number of interesting experiments which we can carry out on ourselves or on one another to prove this.

For instance, the fingers are much more sensitive to touch than the toes. Shut your eyes and hold out your hand extended. Then ask a friend to touch one of your fingers. You can detect, without seeing, which finger was touched.

Now take off your sock or stocking and ask your friend to touch one of your toes, the second, third or fourth. Of course, you keep your eyes shut as before, and you will probably be quite unable to say which toe was touched.

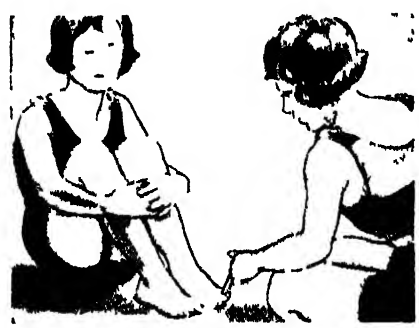
We can carry out still another experiment in touching the fingers. This time we cross the middle and ring fingers, and then, closing our eyes, get our friend to touch the tip of one of these. We shall find it much more difficult to be sure which finger was touched than when they were uncrossed. Of course, in these experiments we touch only for a moment.

Now we can carry out some interesting experiments on ourselves with an ordinary pair of pointer compasses.

When the fingers are crossed it is less easy to know which of them is touched

We test various parts, such as our tongue, finger tip, lip, nose, palm, back of the hand and back of the neck, seeing how close together we can keep the compass arms and yet feel the two points.

We shall find that the tongue is by far the most sensitive part, and when the two points are only one twentieth of an inch apart they will be felt as two distinct points. At the tip of the finger they must be a twelfth of an inch apart for the two points to be detected separately. On the under lip we must open them to one sixth of an inch, and on the tip of the nose to a quarter of an inch. When we come to the hand we



It is hard to guess which toe is touched

find that that is much less sensitive than the parts we have already touched. Here the points will have to be at least half an inch apart when we touch the palm if we are to feel the two points. On the back of the hand it is necessary to have the points an inch apart, and at the back of the neck we must open them to about two inches. We can carry the experiments still further by trying the compasses on other parts.

Now we can understand why a blind man uses his finger tips so much.

A number of interesting experiments which we can carry out on different parts of our body with a pair of compasses. The compasses have to be opened more and more if we are to detect the two points as we touch the less sensitive parts of our skin

WHAT SEAWEEDS LOOK LIKE WHEN THEY ARE GROWING

We generally see the seaweeds at a disadvantage for to most of us they are only known by fragments thrown up on the beach or by one or two kinds that cluster round groynes and piers If we could only see them as they grow in the sea we should be surprised at their variety and beauty This picture gives us some idea of what familiar seaweeds look like in their native home All the species shown are found round the British coasts Of course, none of the British seaweeds grows to any very great size, but in other seas there are some enormous seaweeds The tallest of all living things is a seaweed Sir Ernest Shackleton found a gigantic marine forest near Tierra del Fuego in South America which included giant seaweeds that were 600 feet high, or more than four times as high as Nelson s Column Although the simplest plants that live an independent life are found among the seaweeds, there are many seaweeds which are far more advanced and have stems and leaves and a kind of root, which however, is only to help them to hold fast to the rock or sea-bed Green seaweeds are most abundant in shallow water and red ones in deeper water The brown seaweeds are generally found growing midway

THE HOLLY THAT PRACTISES PARTIAL DISARMAMENT

THE holly which is quite a common plant in the countryside but is known to town dwellers chiefly at Christmas time is a very interesting plant It is usually seen in gardens as a bush but when allowed to grow freely in congenial surroundings it becomes a tall tree forty or fifty feet high and when covered with bright red berries is a truly fine sight

The holly in full flower

It makes a splendid hedge though we usually see holly hedges clipped into formal shapes which spoil the beauty of the plant If it were not for the fact that it grows very slowly and is difficult to transplant safely after it has reached a considerable size it would be more used for hedgerows than the hawthorn

John Evelyn the diarist and friend of Samuel Pepys who was very fond of trees and had a magnificent hedge of holly in his garden wrote Is there under Heaven a more glorious and refreshing object of the kind ?

The spines of the leaves are the plant s natural defences against enemies for without these cattle would browse upon the foliage Where the tree grows tall the upper leaves are often without these spines and some botanists declare that the spines are not produced high up because there the leaves are out of reach of foes

The clusters of white flowers develop into the rich scarlet berries which we know so well Unlike the red berries of the hawthorn and the mountain ash which are soon carried off by birds the holly berries generally remain on the tree through the winter unless owing to hard frosts the birds cannot get other food then they take the holly berries

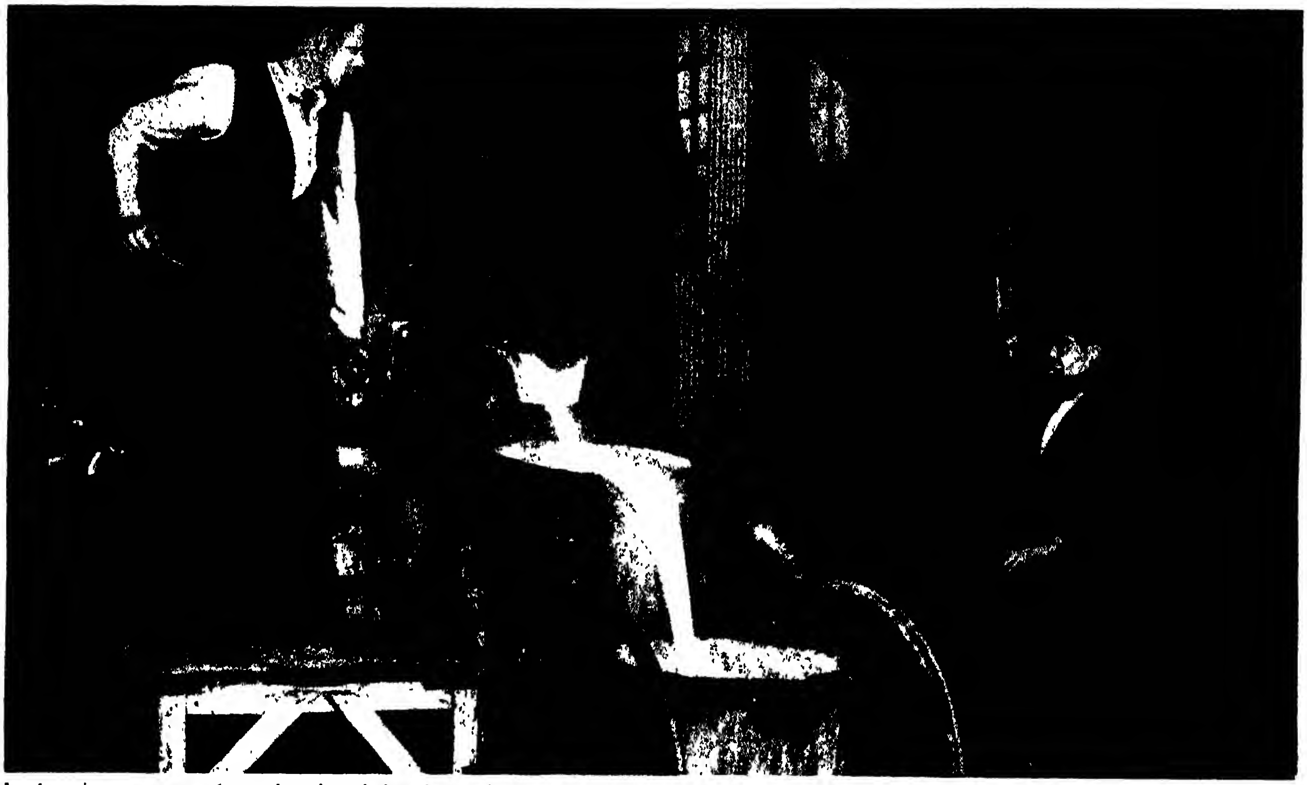
The timber of holly is very white and hard and is much used by cabinet makers for ornamental work When stained black it looks like ebony

The red holly berries or fruits

EDIBLE FUNGI THAT GROW IN ENGLAND

The poet Shelley has described fungi as "plants at whose name the verse feels loath," but really these plants are as interesting and beautiful as others. Some are poisonous, but plenty of edible fungi grow in England Sixteen are shown here 1 Common Mushroom (Psaliota campestris) 2 Shaggy Caps (Coprinus comatus) 3 The Chantarelle (Cantharellus cibarius) 4 Amethyst Agaric (Tricholoma nudum) 5 Horn-of-Plenty (Craterellus cornucopioides) 6 Warty Caps (Amanita rubescens) 7 The Common Morel (Morchella rotunda) 8 Giant Puffball (Lycoperdon giganteum) 9 Horse Mushroom (Psaliota arvensis) 10 Edible Boletus (Boletus edulis) 11 The Fairy Ring Mushroom (Marasmius oreades) 12 Parasol Mushroom (Lepiota procera) 13 Funnel Agaric (Clitocybe maxima) 14. Sheathed Agaric (Amanitopsis fulva) 15 Blewits (Tricholoma personatum) 16. Scaly Agaric (Lepiota rhacodes)

DRAWING MOLTEN METAL FROM A FURNACE



In this picture we see the molten iron being drawn from a blast furnace at a Surrey foundry. As can be seen, the metal flows like water and when it is drawn off it is allowed to run first of all into one vessel and then it is poured from that into another on wheels, so that it can be wheeled away for pouring into moulds. Of course a foundry of this kind is on a much smaller scale than the huge blast furnaces of the North, where the metal is run into troughs so as to form bars that are known as sows and pigs

When cast iron is made from ore there is a great deal of impurity in addition to the metal. This, being lighter than the iron, floats on top of the molten mass, which makes it easy to collect. It is drawn from an opening in the furnace, being blown off the metal by a blast of air. It then flows down as shown in this picture and solidifies. Of course, as can be understood, very great heat is needed in blast furnaces to melt the ore and extract the iron. The melting point of iron is 2,768 degrees Fahrenheit

MARVELS of MACHINERY

THE VAST IMPORTANCE OF IRON & STEEL

The whole of our marvellous modern machinery is dependent almost entirely upon a single metal, and that is iron. Without iron we could have neither railway engines, nor printing machines, nor giant skyscrapers, nor iron or steel bridges. In these pages we read and see how iron is obtained from the ore and cast ready for use.

HAVE you ever thought that iron is the most important metal in the world? We often think of gold as being of great value, and of course it is a medium of exchange, that is, a means of reckoning the value of all sorts of goods and materials; it is. But if gold had never been discovered at all we should probably have been none the worse off; some other medium of exchange would have been used.

The case is quite different with iron. If iron had never been discovered nothing else could have taken its place, and civilisation could not have progressed as it has done.

Dr. Newton Friend, a great authority on the subject, has well said: "It is safe to assert that the wonderful progress which has marked our path during the last hundred years would not have been possible had not the earth possessed an abundant supply of iron ore."

In whichever direction we cast our eyes, articles of iron, large and small, essential and ornamental, meet our gaze. It is iron in some form or other that constitutes the essential framework both of our railways and of our mercantile marine. Without these rapid means of transport the huge populations of London and our larger cities could not be fed and supplied with the necessaries of civilised life as we know it today.

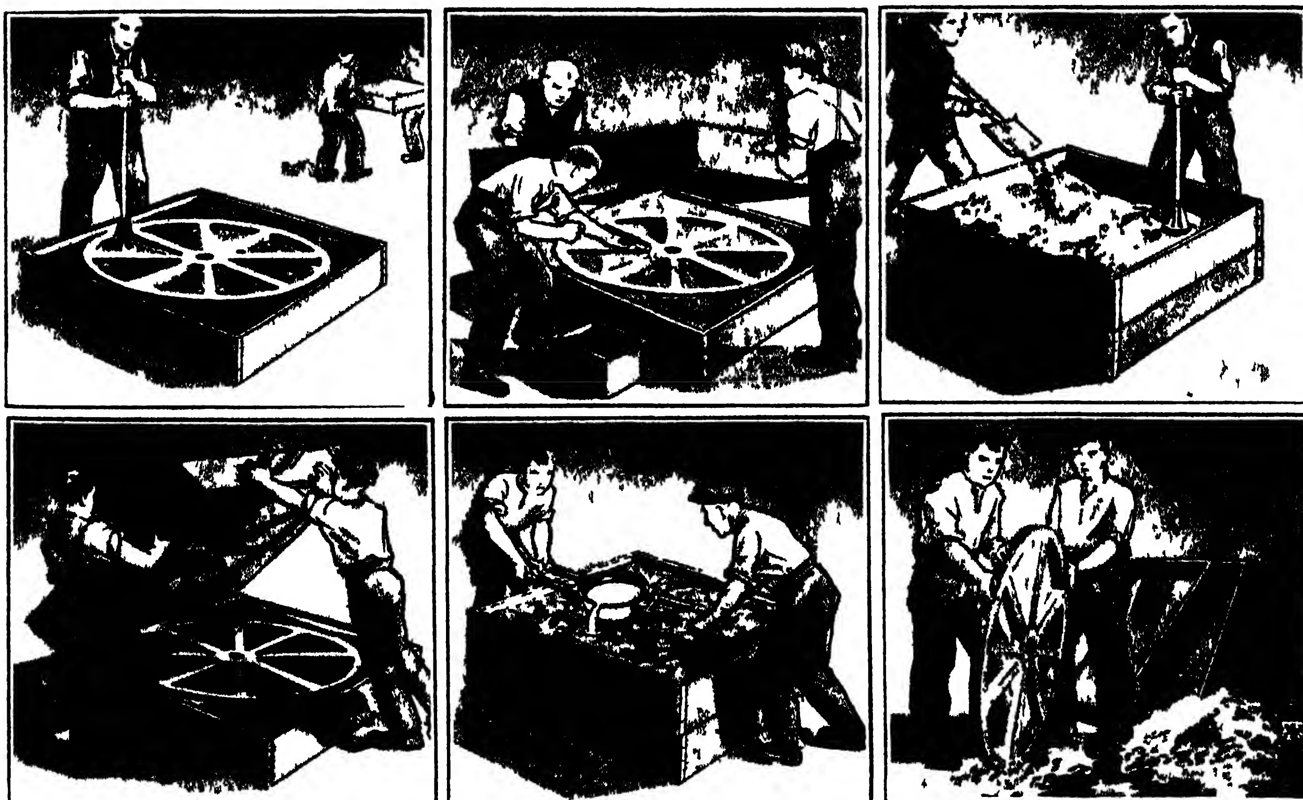
Without iron we certainly could not have the marvellous machinery that does such wonderful service for us, and if we look round our homes and see the fireplaces and gas stoves, and coal scuttles and saucepans, and knife blades and hammers, and nails and screws, and scores of other articles, we realise how much we owe to iron.

It is believed that the first iron ever used by man was from meteorites, but very early he learned to get it by melting ore, though how he made that discovery no one knows.

But although iron has been used for centuries, we may be proud that it was the English who showed the world how to make cheap iron and steel with coal. Less than a couple of centuries ago a furnace turned out about a ton and a half of iron a week. The fuel used was charcoal.

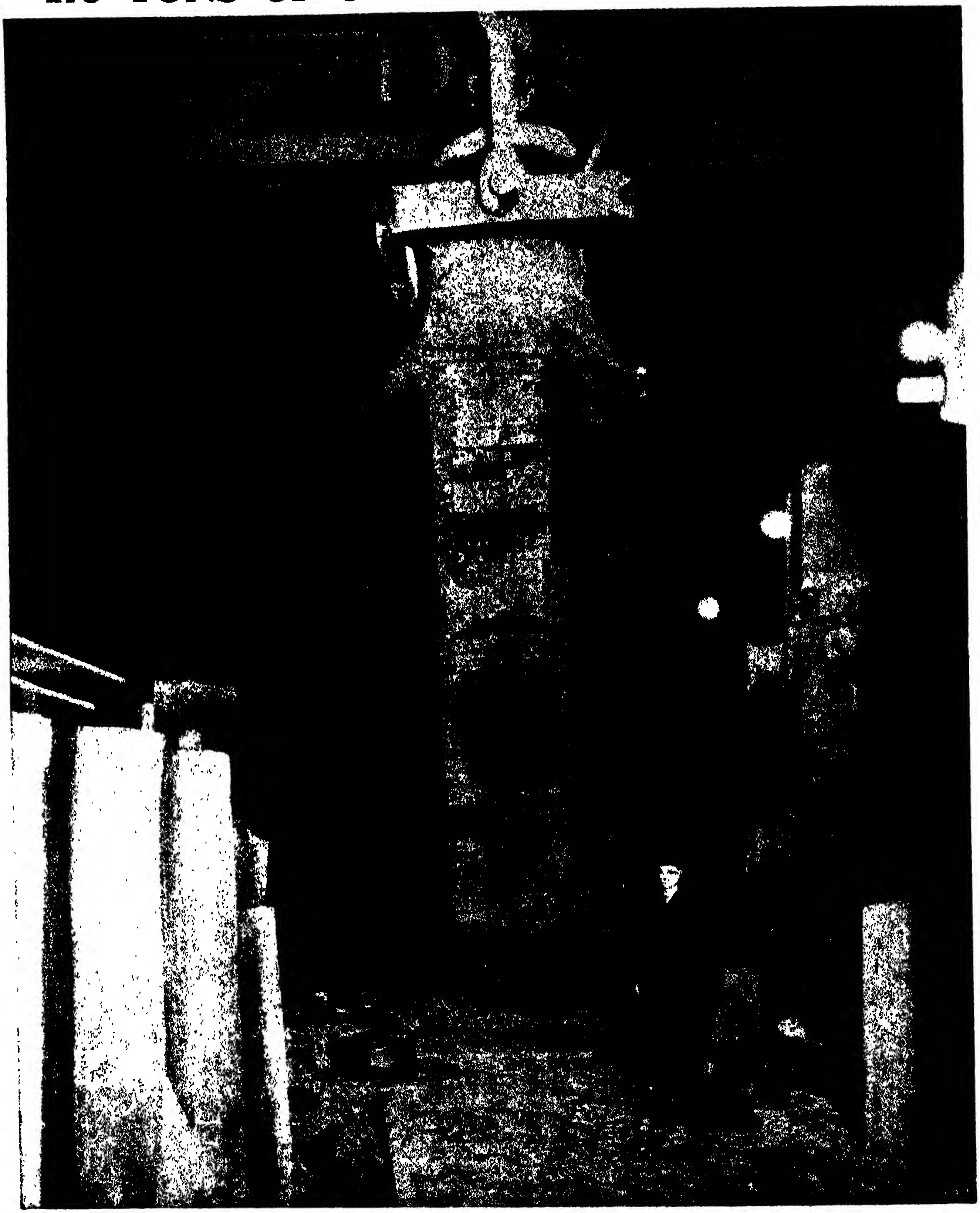
By 1790 a coke-fired furnace was able to produce 17 tons of iron a week, and in 1930 the world's output was 81 million tons.

What we want to remember is that it was England which gave the world the modern blast furnace for producing pig iron cheaply and in great quantities, and both the Bessemer and open hearth processes of producing steel cheaply and quickly. Without these great inventions the engineer would have been helpless.



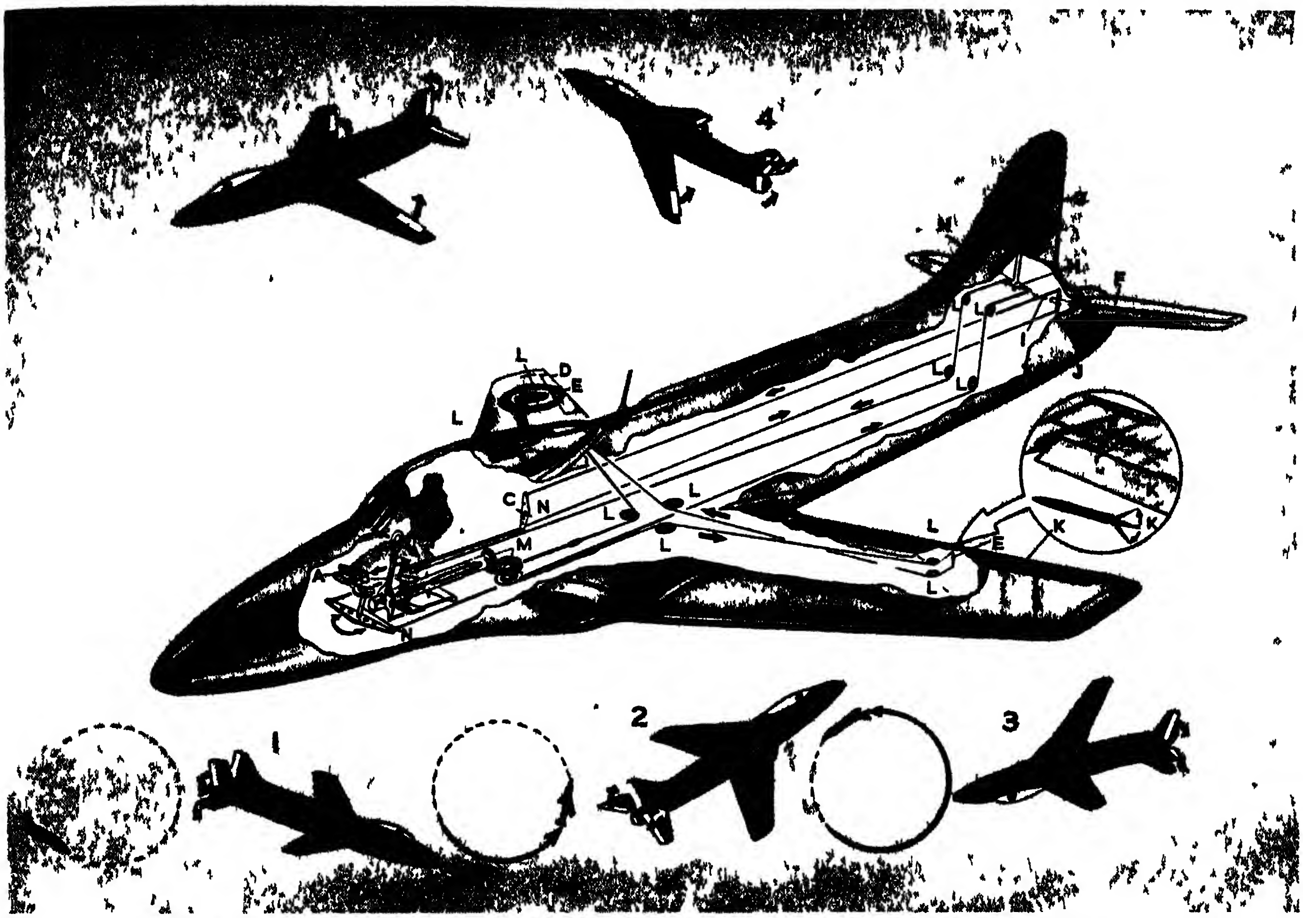
In these pictures we see workmen making a cast iron wheel. First a mould for casting the wheel is made by packing sand in a frame round a wooden pattern. In the second picture another frame is being placed on top to be filled with sand. The pattern is sprinkled with powdered charcoal, so that the sand will not stick to it. In the third picture the workmen are moulding the sand in the second frame. In the fourth picture the top frame is being lifted, so that the wooden pattern may be removed and the space left ready for the molten metal. The next picture shows the upper frame replaced and molten iron being poured through a hole to fill the space made by the pattern. When the molten metal is cold, the frames are removed and the cast iron wheel taken out, as in the last picture.

175 TONS OF STEEL CAST IN ONE PIECE



This photograph shows a remarkable ingot of steel weighing 175 tons, just after it had been lifted by a 200-ton crane from the mould in which it had been cast. It was then taken away and lifted by another 200-ton crane into an annealing furnace to be toughened and tempered by gradually diminishing heat. After other treatment it was reheated and forged into the required shape by a powerful hydraulic press. The heat thrown off by such an ingot is terrific, and makes it exceedingly difficult to shape correctly. The ingot was cast at a steelworks in Sheffield and was one of the largest single pieces of steel ever made in Britain. The achievement was also remarkable in that the ingot did not contain a single flaw after it had cooled.

HOW AN AEROPLANE IS CONTROLLED IN FLIGHT



This picture diagram shows the various controls of a jet-propelled fighter aircraft and how they are operated by the pilot A, rudder bar, B, control column or joystick, C, bell crank for moving elevator, D, starboard (right-hand) aileron, E, operating arm for aileron control, F, left-hand elevator, G, rudder, H, swivel controlled by cables operating elevators, I, link joining left and right elevators, J, lever which is moved by cable from cockpit and controls elevators, K, port (left-hand) aileron, L, pulleys for control cables, M aileron operating gear, N, pivot for rudder bar The small circular diagram gives a more detailed view of an aileron assembly The silhouette (black) drawings show the position of the aircraft for various manœuvres 1, diving to gain speed for a climb preparatory to looping the loop, 2, beginning to loop, 3, aircraft at top of loop, 4 a climbing turn to the left, 5, a side slip to the left to lose height

An aeroplane is kept in flight and manœuvred by the tail plane rudder elevators and fin

In a single seat monoplane as illustrated above the fuselage which carries the engine and pilot tapers to the rear where is mounted the upright fin The fin stops the aircraft swaying from side to side The end of the fin is hinged to form a rudder which can be moved left or right

Attached to each side of the rudder is a strong wire and these wires are led through the fuselage to the cockpit where they are fixed on to either side of the ends of the rudder bar against which the pilot rests his feet The rudder is moved by the pilot pushing one foot or the other against the rudder bar so pulling the rudder to left or right

Because of its high speed an aeroplane could not easily be turned simply by moving the rudder, so the rudder is helped by banking, or canting the aeroplane over, just as a cyclist banks when taking corners at speed

Part of the rear or trailing edge of each wing is in a separate piece and hinged to the main wing These hinged pieces called ailerons are connected by wires to the joystick the latter can be moved backwards or forwards or from side to side

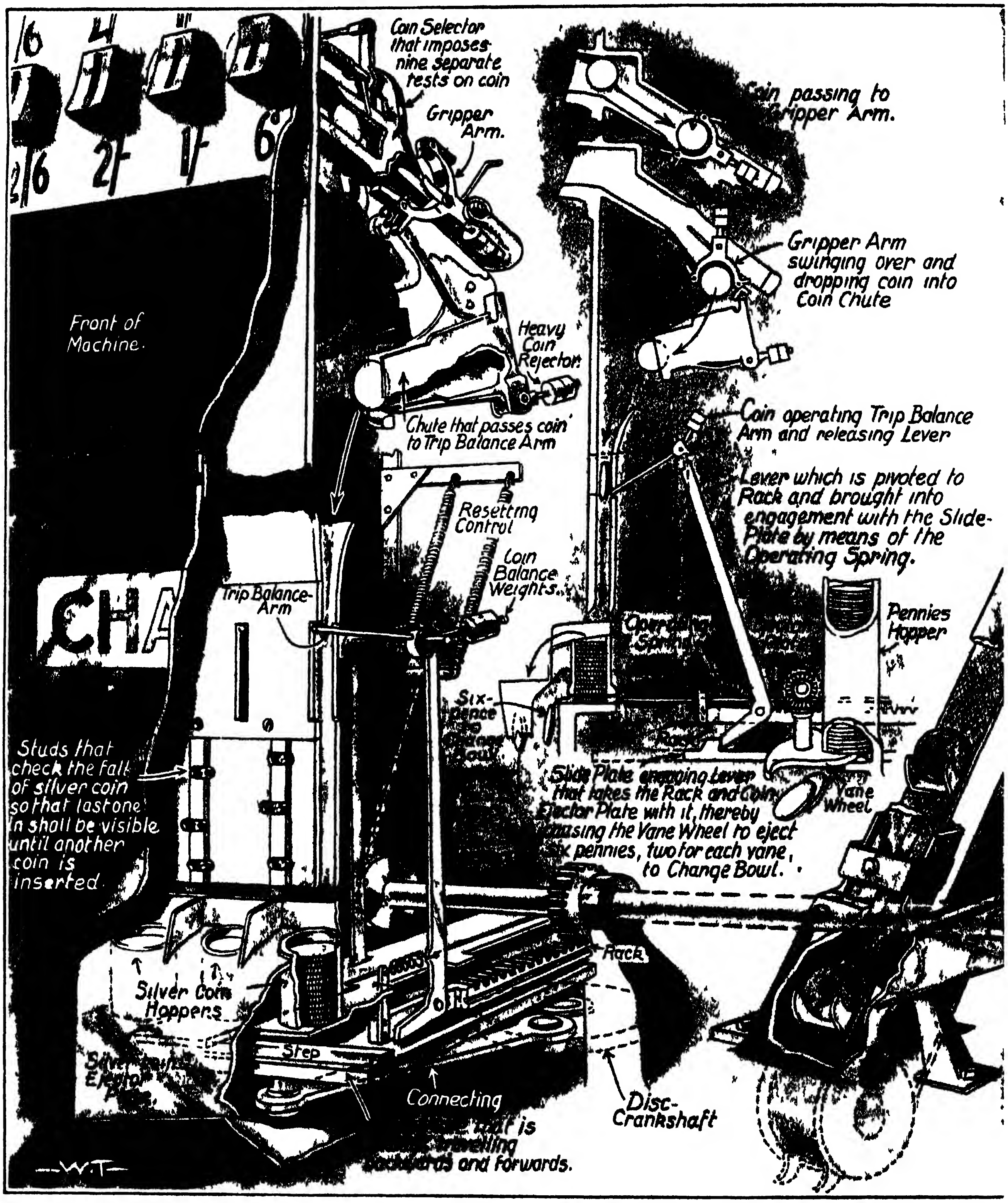
Movement of the joystick sideways to the left raises the left aileron and lowers the right one Air pressure against the lowered aileron then forces the right wing up and the left wing down This makes the aeroplane lean over or bank to the left while at the same time the pilot's left foot pushes the rudder bar forward and so pulls the rudder to the left which completes the manœuvre and turns the whole aircraft to the left Reversing these operations turns the aeroplane to the right With joystick upright and rudder bar level the aeroplane flies on a straight course

Climbing and diving are by use of the elevators two flat surfaces hinged to the rear edges of the tailplane one on each side of the fin and connected by wires to the joystick To climb the pilot pulls the joystick towards him so pulling up the elevators The air then presses down against the upper surfaces of the elevators so forcing the tail down The nose of the aeroplane tilts up and the machine begins to climb Climbing is assisted by increasing speed To dive the pilot pushes the joystick away from him so turning the elevators down the tail rises the nose dips and the aircraft begins gliding to earth

It is always safest to land an aeroplane at a slow speed and to assist in this there is a hinged flap (not shown in the diagram) on each wing between the fuselage and the ailerons When the pilot pulls a lever the flaps turn down so offering strong resistance to the air rushing past the wings and acting as a brake on the aeroplanes speed

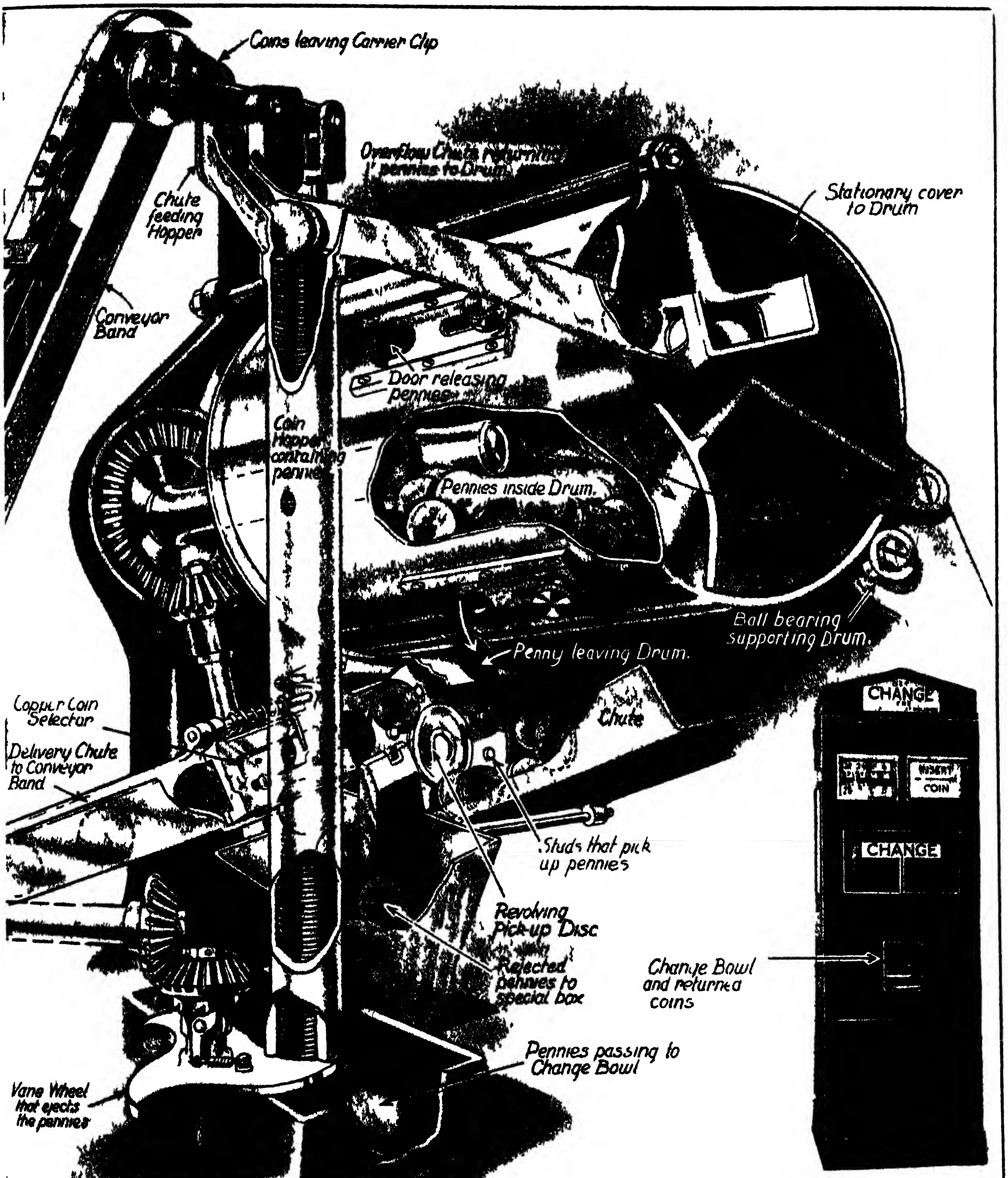
Large aircraft particularly those with several engines sometimes have two or more sets of fins rudders and elevators all in line with one another and operated by mechanical power The joystick is often replaced by levers and there is a wheel instead of a rudder bar In principal however function and operation of aircraft controls are the same irrespective of the size or type of the aeroplane

THE MARVELLOUS MACHINE THAT GIVES



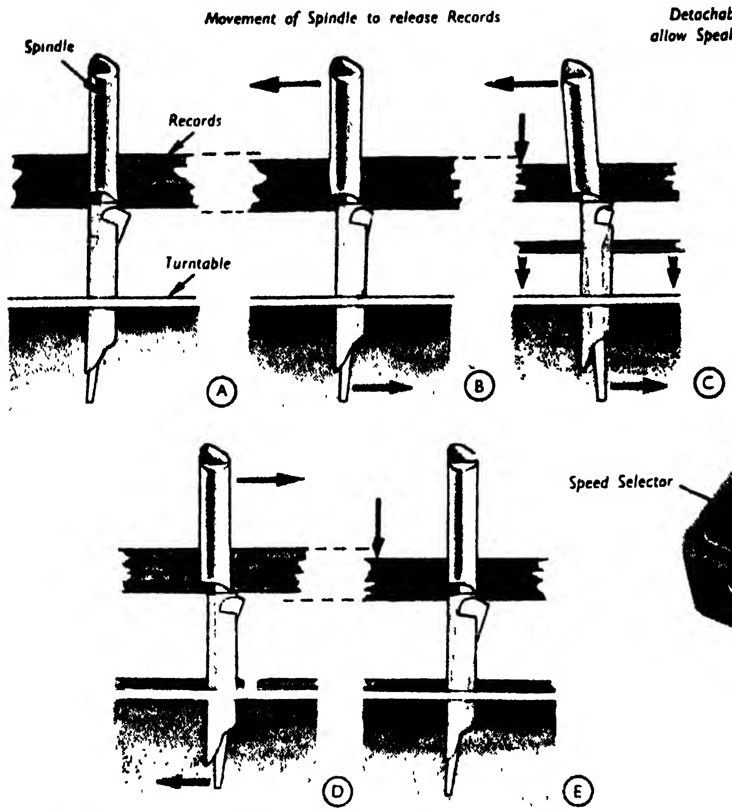
This picture which runs across two pages explains how the marvellous change-giving machine at London railway stations, works To make the machine ready a quantity of pennies say five pounds worth is put into the drum. Then the motor is started, and this is so geared that the drum conveyor band and disc crankshaft shown at the bottom of the left-hand page are set in motion As the drum revolves pennies fall from small doors placed as shown on to a sloping chute and thence fall against the revolving pick-up disc where they are picked up by the studs and thrown off into the copper coin selector This selector passes all the perfect pennies but holds the bent or damaged coins and also allows thin coins to drop out through a slot at the bottom as shown The coin selector opens like a hinge at every revolution of the revolving pick-up disc, thus releasing a bent or damaged coin if one happens to be there All faulty coins fall into a special chute and thence into a special box, so that they are unable to leave the machine as change The good pennies next pass by way of the delivery chute to the conveyor band, and are carried to the top of the machine there falling into a chute feeding hopper and then into the coin hopper until it is full up Any surplus pennies pass on by way of the overflow chute back into the drum Now we come to the silver coin part of the machine which only operates when a silver coin, either a half-crown, two shilling piece shilling or sixpence is put into one of the slots What happens can be seen in the left-hand part of the picture. The weight of

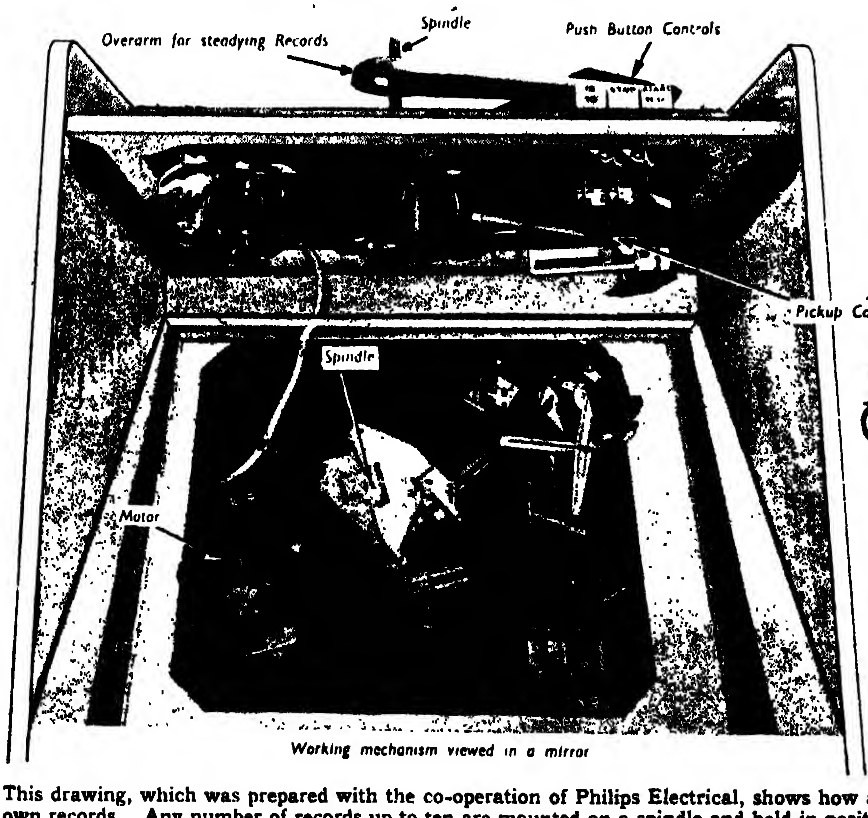
YOU COPPERS IN EXCHANGE FOR SILVER



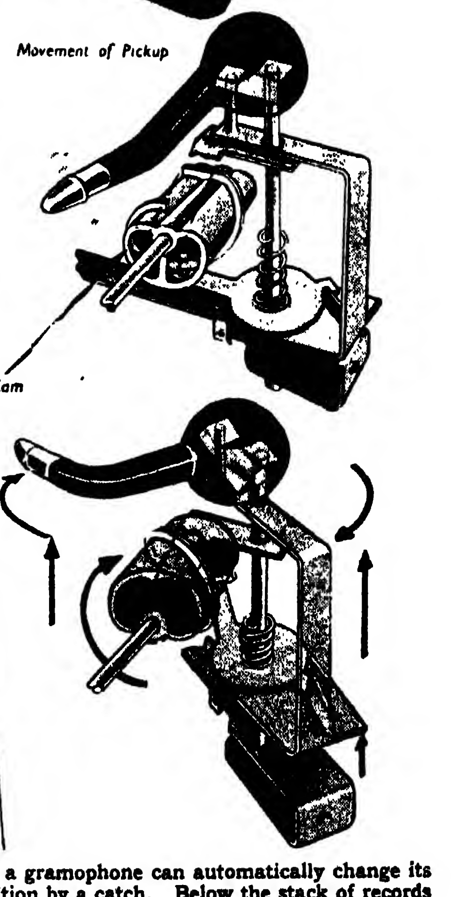
the coin as it passes various points starts a sequence of operations Let us bear in mind that the disc-crankshaft shown on the left by means of the connecting rod causes the slide plate with its step to be moving continuously backwards and forwards It will be seen that when it engages a lever, one of four similar levers, it causes the required silver change to be pushed out from the bottom of the silver coin hopper into the change bowl by means of the ejector plate The silver coin ejector plates are coupled together in such a way that on the insertion of say a two shilling piece in its particular slot, the shilling and sixpence ejector plates will also operate The sixpence ejector mechanism is always operating no matter what silver coin is inserted and this unit by means of the rack operates the vane wheel, as shown and pushes the pennies six in all into the change bowl Of course, in the drawing it has been impossible to show the various parts of the machine in their actual positions The detailed drawings in the middle of the picture show how the silver coin after passing through the selector, goes to a gripper arm which swings over and drops the coin into the coin chute As the coin falls it operates a trip balance arm and releases a lever which is pivoted to a rack The lever is brought into engagement with the slide plate by means of a spring The rack and coin ejector plate are thereby moved and the vane wheel is made to eject six pennies two for each vane Our artist had the courteous help of the manufacturers Messrs Brecknell, Munro & Rogers (1928) Ltd , of Bristol

RADIOGRAM THAT CHANGES ITS OWN RECORDS





Working mechanism viewed in a mirror



This drawing, which was prepared with the co-operation of Philips Electrical, shows how a gramophone can automatically change its own records. Any number of records up to ten are mounted on a spindle and held in position by a catch. Below the stack of records is the turntable on which a record is played. Immediately the pickup arm is moved to the turntable, the record on the bottom of the pile falls on to the turntable. When the record has been played, the pickup arm swings out of the way and actuates a system of cams and springs which close the catch on the spindle and release another record. The pickup arm then moves back to the turntable and plays the new record. This process is repeated as many times as there are records on the spindle. The five drawings A to E show how the records are released by the spindle mechanism on to the turntable. The top right-hand illustration is of the radiogram itself; the bottom left-hand illustration shows the underneath part of the turntable; and the two bottom right-hand drawings show the movements of the pickup arm

THE TWO ROSES LINKED AT LAST

Civil war is the most terrible of all wars and England suffered badly during the long Wars of the Roses. It was a great thing for the country when at last Henry of Richmond, the son of Edmund Tudor, a Welshman, and head of the Red Rose faction, finally gained the upper hand, and by marrying Elizabeth of York, linked the two Roses and reigned over a united kingdom. Shakespeare in his "King Richard the Third" tells the story in dramatic form and here we have it as a narrative

Less than two years and a half after Richard Crookback had seized the crown he was defeated and slain on Bosworth Field, and Henry Richmond, son of Edmund Tudor, a Welshman who represented the Red Rose cause became king

By marrying Elizabeth of York, the daughter of Edward the Fourth and sister of the little princes murdered in the Tower he linked the two Roses and united the nation once more Further the Welsh now that a country man of theirs was on the throne of England no longer regarded themselves as a conquered people but as part of the same nation and from then onward we hear no more of trouble in Wales

Henry was by no means an interesting or heroic character Nor on the other hand was he a vindictive or bloodthirsty man like Richard the Third or Edward the Fourth He had a good deal of shrewd wisdom as was proved by his taking Elizabeth of York for a wife He also very wisely summoned Parliament and persuaded it to pass an Act in which it was declared that "the inheritance of the crown shall be, rest remain and abide in the most royal person of our Sovereign Lord King Henry the Seventh and his heirs perpetually with the grace of God so to endure, and in no other"

The mass of the people were delighted at the union of the two Roses and we get the feeling set forth in the old rhyme

From town to town, from tower to tower,
The Red Rose is a gladsome flower
Her thirty years of winter past,
The Red Rose is revived at last
She lifts her head for endless spring,
For everlasting blossoming
Both Roses flourish, Red and White,
In love and sisterly delight,
The two that were at strife are blended,
And all old troubles now are ended

But Henry was very careful not to marry Elizabeth at once on his accession He wanted to make it quite clear that he held the crown in his own right and not because he had married the daughter of King Edward the Fourth This was important, for had he acknowledged that the Yorkists had any right to the crown he might have found himself in difficulties since there were others living who could claim it on that ground

The strength of the nobles who had hitherto divided power with the King had been crippled in the Wars of the Roses and Henry decided still further to reduce their power by linking himself more with the Middle Classes, the rich merchants of the towns and the farmers and yeomen of the country who were now beginning to rise into importance This was really a good thing in the long run for the country though some of the nobles suffered in the process

On one occasion, for example Henry paid a visit to the Earl of Oxford, one of his great supporters The Earl received him with much honour and pageantry, and had drawn up two long

The last charge of Richard III at the battle of Bosworth. Crying "Treason! Treason!" he rushed at Henry Richmond and was slain almost at once

lines of retainers wearing his livery to receive the King When he was about to leave, Henry asked the Earl if all these men were his household servants, and when he heard that they were not servants but retainers, he said "I thank you, my lord, for your good cheer, but I may not endure to have my laws broken in my sight My attorney must speak with you"

There was a law against the nobles keeping bands of retainers and armed followers, and the Earl of Oxford had to pay a fine of £10,000, and was perhaps lucky to escape without losing his head

We should not have liked to have lived in those days, for while there was much magnificence and display there was very little comfort and not much cleanliness In fact cleanliness seems to have been an almost unknown art The homes even of the nobility were dreadfully dirty and often when a lord and his followers had lived in one of his mansions for any length of time it became so filthy that he found it necessary to move on to one of his other homes

The Earl of Northumberland who lived at this time has left an interesting and curious book behind him from which we can learn a great deal about the way of living of a great lord When he moved from house to house he took his bed, tables chairs, and kitchen utensils with him

Fires made of green wood were very smoky affairs, and no doubt the pots and pans became very black Probably on this account the servants who looked after the kitchen things were called the "black guard" They were the lowest people of the household and in the course of time any low, coarse person came to be known as a blackguard

Queer Breakfast Fare

The Earl and his Countess had breakfast every day at seven o'clock and there was set for them a quart of beer, a quart of wine and half a chine of boiled beef or mutton On Fast Days salt or fresh fish took the place of the meat The servants had to live on salt meat nearly all the year round for men had not yet learnt how to feed cattle through the winter months when the grass does not grow There were also very few vegetables

No matter how cold the weather happened to be no fires were allowed after Lady Day, except for the Earl and Countess and their children The washing bill for the household which consisted of 166 persons, apart from

visitors was very small. It was forty shillings a year and that included the linen used in the chapel services. There were only nine tablecloths in the household and no sheets at all.

The same way of life continued right down to Queen Elizabeth's time, and an old writer of her day says: "With continual usage the house waxed unsavoury. Hence it became necessary to move on to another."

Henry realised that after all the loss and waste of the Civil War a reserve must be built up, and he began to accumulate money, which proved very useful to his son. When he died he left his son £1,800,000, a vast amount for those days. This sum he accumulated by methods that would not be tolerated nowadays. Once he pretended to be going to war with France and summoned Parliament to vote him supplies for the purpose. Then when he received the money he did not go to war, but kept the supplies.

His chief minister, Cardinal Morton, the bishop of Ely, who grew such fine strawberries in Holborn that Richard the Third while at a Council asked him to send for some (see page 410), and who afterwards became Archbishop of Canterbury, helped Henry in his money-making schemes.

There was a system known as benevolences, that is, rich men were asked to make a present of money to the King. It was described as purely a gift, but woe betide the subject who did not pay up. If a man made a great show, then he was asked to pay a large sum to the King, for it was obvious he must be very rich or he could not keep up such a show. If, on the other hand, he lived quietly and frugally, he also was asked to pay a great sum, because it was obvious that as he spent so little he must save the more.

Morton was very clever in getting money for the King from both sorts of people, and so men came to speak of Morton's fork, meaning that if a man could slip off the prong of extravagance he got caught on the other prong of frugality.

Those days in which Henry lived were a turning point in the history of the world. Three very great things happened during his reign, though Englishmen had nothing to do with them directly. America was discovered, Constantinople was taken by the Turks, and scholars as a consequence were driven with their learning to Western Europe, and finally Modern Science was begun with the discovery that the Earth was not the centre of the Universe, and that the planets moved round the Sun. With the coming of these things the old order passed, and a new day began to dawn for the world.

Ferdinand and Isabella of Spain got the credit for fitting out Columbus's expedition to America, but Henry the Seventh nearly had that honour. Columbus had first applied without success to Genoa and then to Portugal, and finally to Spain for help, but when they all refused, in sheer desperation he at last sent his brother Bartholomew to England to see if King Henry the Seventh would help. It is quite possible that Henry would have done so, but unfortunately Bartholomew fell among pirates during his journey, and when he arrived in London he was in such a miserable plight that he could not appear before the King. He therefore spent a good deal of time drawing and selling maps in order to make enough money to clothe himself properly.

At last he obtained an interview with the King, who received him favourably, but meanwhile Columbus, not hearing from his brother, applied to Queen Isabella of Castile, and she agreed to help him. So the discovery of America must be placed to the credit of Columbus, who was born a Genoese, and to the Spanish sovereigns.

Later Henry did send out an expedition to the New World under the leadership of Sebastian Cabot, a Venetian who had settled in England. That explorer discovered Newfoundland, which became the nucleus of England's great overseas empire.

Henry did all he could to strengthen his throne, and at his death he left it more powerful than it had ever been before; nevertheless his reign was not untroubled with claimants to the throne. There were two great rebellions, both, strangely enough, centring round impostors.

The first of these was rather a handsome, pleasant youth who was born at Oxford. He was of lowly origin, but we are not quite sure whether his father was a baker or carpenter or shoemaker or organ builder. He is given all these descriptions in one or other of the old chronicles.

The boy, called Lambert Simnel, was fifteen when he fell into the hands of an Irish priest named Richard Simon. Simon thought out a rather mad scheme by which he hoped to advance himself.

In the Tower of London, kept a close prisoner, was the Earl of Warwick, the young son of Edward the Fourth's brother the Duke of Clarence, who had been drowned in a butt of Malmsey wine. He had committed no offence

The union of the Red and White Roses of England by the marriage of Henry VII and Elizabeth of York. From the painting by Brown

but King Henry thought it wise to keep him under lock and key or some discontented party might one day want to make him King.

Simon's idea was to train young Simnel to impersonate the Earl of Warwick and then to put him forward as the Yorkist claimant to the throne. He had at first intended to make Simnel impersonate Richard Duke of York, the little prince smothered by Richard the Third's orders, but afterwards he changed his mind.

Teaching an Impostor

Simon took Lambert Simnel over to Ireland and schooled him in the part he was to play. Then the priest went to the Earl of Kildare, who was Governor or Lord Deputy of Ireland and a great supporter of the House of York, and told him that the young Earl of Warwick had escaped from the Tower of London and was now in Ireland. He presented his protégé to the Earl, and it is quite possible that the Lord Deputy really believed that the young man was the Yorkist heir. At any rate he professed to believe it and determined to put him on the throne. Simnel was crowned as King in Dublin.

Margaret of Burgundy, who was the sister of Edward the Fourth and hated Henry the Seventh with a deadly hatred, lent her aid and sent over 1,500 well trained German soldiers to assist in placing Simnel, or as he professed to regard him, her nephew the Earl of Warwick, on the English throne.

News of what was happening had reached Henry, and he did a very sensible thing. He took the real Earl of Warwick out of the Tower, paraded him through the streets of London and allowed a number of people to speak with him. Then the young prince was returned once more to the Tower and kept in close confinement.

Simnel Taken Prisoner

A few weeks later Simon with Lambert Simnel and an army crossed to Lancashire and landed near Furness, where they were met by a number of Yorkist supporters. They marched through Yorkshire and at Stoke, near Newark in Nottinghamshire, met the King's army. A hotly contested battle was fought which lasted for three hours, but although the Germans fought well Henry's forces triumphed and both Simon and Lambert Simnel were taken prisoners.

The king then showed that he was a very different type of man from some of his predecessors on the throne. He was not at all vindictive. Simon the priest was sent to prison for the rest of his life, but for young Simnel a very curious fate was reserved.

The King's Joke

Some of the nobles who had taken part in the rebellion were commanded to attend the King's Court in London. There they were invited to a great dinner given by the King, and as they sat at the meal a serving boy came round, as was the custom, bearing a wine cup. As the noblemen looked at this boy they seemed to recognise his face. It was Lambert Simnel, the false Earl of Warwick, for whom they

Lambert Simnel instead of being executed was made a scullion in the King's kitchen, where part of his duty was to turn the spits

had been fighting and on whose account they had been fined large sums of money by way of punishment. They must have felt very foolish and humiliated.

Henry must have been something of a humorist, for instead of punishing Simnel he had pardoned him and made him a scullion in his kitchen. There part of the youth's duty was to turn the spits on which the birds were roasting before the fire. He did his work well and later seems to have been promoted to the office of falconer, a much more dignified post. In this rather clever way Henry showed his contempt for any who would assail his throne.

As Francis Bacon says:

"For Lambert the King would not take his life, both out of magnanimity, thinking him but as an image of wax that others had tempered and moulded, and likewise out of wisdom, thinking that if he suffered death he would be forgotten too soon. But being alive he would be a continual spectacle and a kind of remedy against the like enchantments of people in time to come."

In all this Henry showed that he possessed real wisdom and was prepared to strike out along new courses without following too closely the behaviour and deeds of his predecessors on the English throne.

A Great Maker of Money

He has been called the "Solomon of England," being accounted by some old writers as one of the wisest princes of his time. But while that title is somewhat of an exaggeration, there is no doubt that Henry by his discreet behaviour not only strengthened his throne but made his country far more united than it had ever been before.

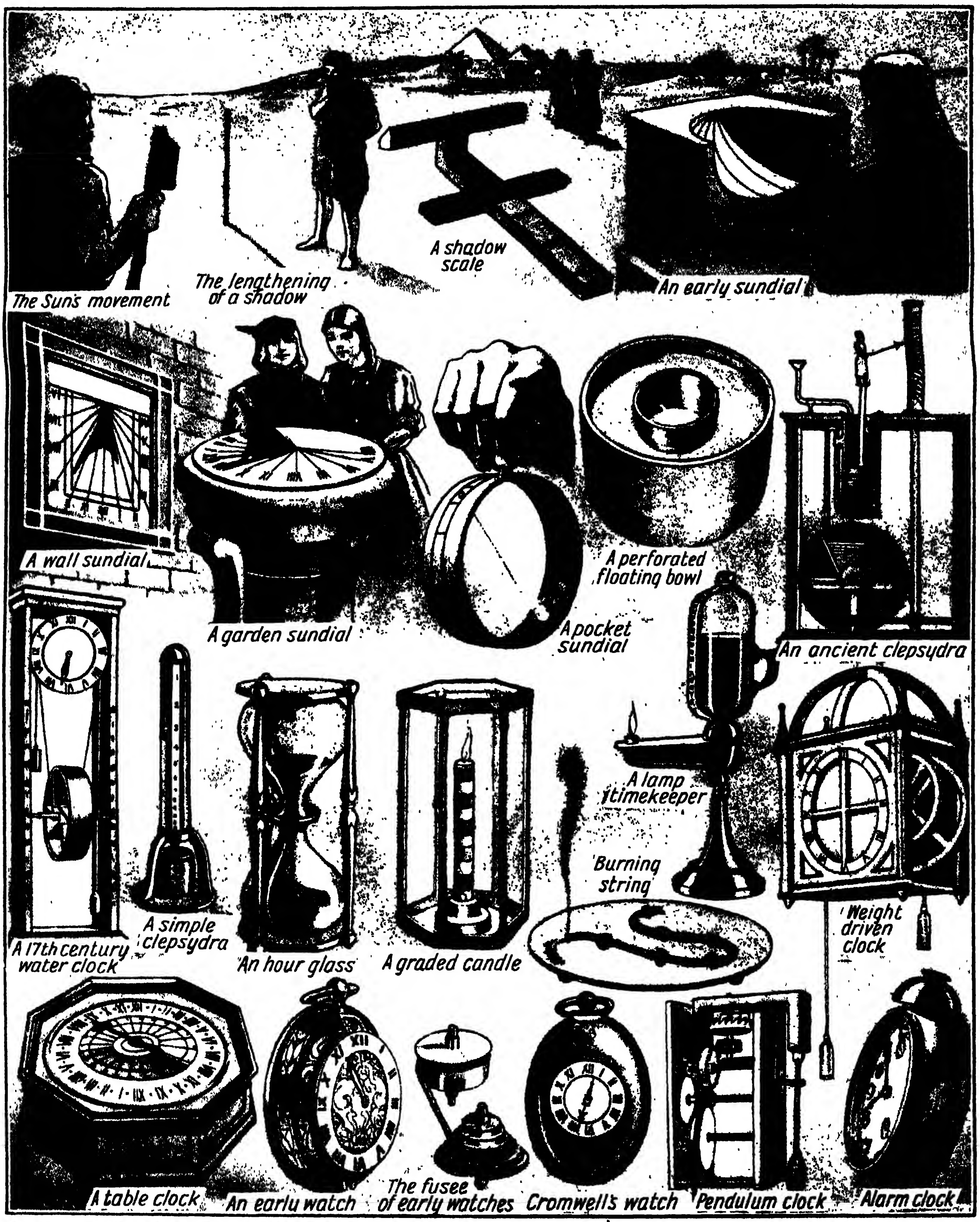
Of course his extortions cannot be overlooked, and they are something of a blot on his reign. But we must remember the times in which he lived, and that even in these matters he behaved with less brutality than many of his predecessors had done. It is something to come to a period in the history of the country when bloodshed is not the main feature of its records.

Even in his private life, of which however we know little, Henry was a great improvement on many of the sovereigns who had gone before him. The greatest weakness of his character was a love of money, which led him to do many things that otherwise he would probably not have done. Of course the accumulation of a huge sum of money in his exchequer helped to strengthen the country and make its financial position stronger than it had been.

Hunting Near Hyde Park

Henry was fond of hunting and used to indulge in this sport very regularly. He introduced to England the French practice of driving game into nets. It seems strange in these days to think that his game preserves, which were well stocked, extended from Hyde Park to Hampstead. We do not associate hunting and game with this district, which now has a teeming population and is covered almost entirely with streets of houses.

HOW MAN HAS TOLD THE TIME THROUGH THE AGES



These pictures show the evolution of the clock, from the far-off days when man first noted the passing of time by watching the Sun's movement in the heavens. Then he noticed that the shadows lengthened as the Sun sank, and the Ancient Egyptians told the time by shadow scales, in which the shadow of a bar passed along a scale as the Sun rose or sank. Sundials followed, and many exist in England to-day. Of course, sundials have to be adjusted to different latitudes. Many other devices have been used for telling the time, such as a bowl slowly filling with water, a dial worked by a float in water, and a burning candle, lamp or string. At last came the clock

THE GREAT MYSTERY OF TIME

What is Time? We shall find it very hard to get or give a really satisfactory definition. The dictionary says "it is a general idea of successive existence, the measure of duration," while a well-known encyclopedia declares that "attempted definitions are too controversial to permit of their being given." We must, however, try to get some definite idea of what Time really is.

To most of us Time probably seems a very simple matter. "What is the time?" we ask, and the reply given by word of mouth or by the face of a clock is that it is noon or two o'clock or some other time.

We ask how long a certain journey takes, and are told two or three hours. Somebody wants to know our age, and we tell them 12 or 15 years or whatever may be correct. Time, therefore, is just the period which elapses between one event and another, as, for example, between our birth and the present moment.

Some people probably think the movement of the hands round the clock face is the same thing as Time, but that is only a way of measuring what we call Time. The clock is a clever device invented by man to mark the passing of Time, so that we may, in dealing with one another, have some regular way of marking Time.

The clock does not make Time but merely tells it, and we know how often clocks go wrong. They may get fast or slow, and, indeed, a clock can be made so that the hands would go round the face in any period we liked. They could go round in a minute or they could take a year to go round.

Of course there is a natural way of measuring Time. The Earth turns round on its axis in 24 hours, and we call the period of one complete turn a day. The Earth travels round the Sun in just over 365 days, and we call that period a year. Then dividing up these into lesser periods, we have a kind of foot-rule with which to measure the passing of events.

What we really mean when we say it is six o'clock in the evening is that it is six hours since the Sun reached its highest point in the sky. Ever since there were intelligent men on the Earth they have measured Time by the Sun. Nowadays, however, astronomers reckon Time even more accurately by means of the stars, but for ordinary purposes we still use the Sun.

In everyday life we do not watch the Sun. We leave the astronomers to do that for us. We watch the clock to get the passing of Time, and we measure it by the passage of the hand round the dial. When the hour hand has passed half round the dial we say six hours have gone, and when it has gone round the dial completely 12 hours have passed. In some clocks, which are 24-hour clocks, it takes 24 hours for the hand to go completely round the dial.

We reckon ordinary events in years, months, weeks and days, and in some cases we measure them by minutes and seconds, as, for example, the time a man takes to run a mile.

In olden days Time was measured by an hour-glass, that is, by the movement of sand from the top bulb of the glass into the bottom bulb; or by the lengthening and shortening of a shadow on the ground or wall; or by the movement of a shadow, as on a sundial; or by the movement of water as it dripped from a little tank into another tank in a water clock; or by the burning of a candle, that is, by the movement of the flame nearer and nearer to the bottom as the candle burned away. In fact, without movement it is impossible to measure Time or even to think of Time.

And this brings us to the very important fact that Time is inseparably bound up with motion. For example, if we set out for the railway station half a mile away and we run or walk

It is impossible to think of Time apart from motion. Here a schoolboy and his sister are going to the station. The girl started earlier, and is walking while the boy, who started some time afterwards, is running. The time they take to get from their house to the station depends upon their motion, and the speed with which they travel to the station depends upon the time they take

quickly all the way we get there in perhaps seven minutes and just catch the train. If on the other hand when we left our house instead of hurrying to the station we had strolled along very slowly the journey might have taken a quarter of an hour and we should have missed to find our train one. The time of making the journey from our house to the station as we can see depend upon our motion and the speed or rate of our travelling depends upon the time occupied.

The Part Played by Time

But what we can all understand is that Time plays a very important part in all our lives. Everything in the universe is in motion from the mightiest star down to the tiniest atom of which our bodies and all things are composed. If the whole universe suddenly became still and motion of every kind ceased then there would be no such thing as Time, for without movement there could be no events and there would be no duration of any kind to measure. To repeat, Time is merely the measuring of movement and without movement there could be no Time.

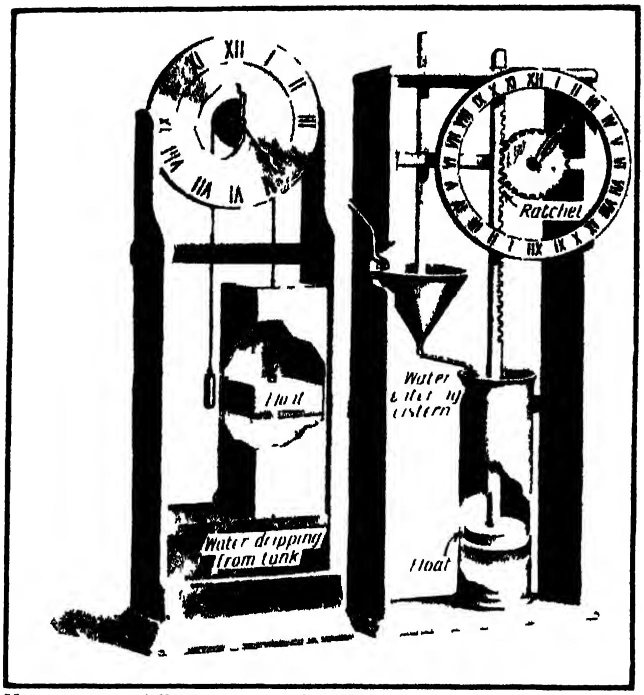
Indeed men of science now speak of Time as the fourth dimension just as a thing has length and breadth and thickness so, they say, it has Time. Some scientists go further. They tell us that the form and substance of a thing depends upon the time taken by the particles of which it is composed in moving from place to place.

How Time Would Cease

Then the amount of material in the body, its mass, as scientists call it, depends on the time the particles take in travelling so that the greater the speed of the particles the greater the mass of the body and the slower the speed the less the mass or amount of material in the body. Carried to its logical conclusion this means that if movement ceased not only would Time cease but the universe itself would cease to exist. This may seem difficult and to understand it thoroughly we should have to know a good deal of the higher mathematics.

When we have a great deal to do and are very busy Time seems to go quickly, but if we are loitering about with nothing to occupy us the Time, as we say, "hangs." The busier we are, that is, the more quickly we move, whether it be our feet or our hands or our bodies or our eyes or the particles of our brain the more quickly does Time seem to pass.

If a man could be confined in a dark dungeon into which no light could penetrate and had an unlimited supply of food there with him so that no one had to visit the cell, he would have no idea of the passing of Time. He would not know whether he had been confined in the dungeon for a month or a year. Of course in actual practice prisoners who have been confined in dark dungeons have gained some idea of the passing of time from the visits of their gaolers with food and water.



Here are two different types of water clock, the earliest form of clock, in which the passing of water in or out of a cistern changes the level of a float, and by a wheel and line, or a ratchet and toothed wheel, moves a hand round a dial. Water clocks are ancient devices, but were revived in the eighteenth century and are still sometimes used

This prisoner in a dungeon would have no possible idea of the passing of time were it not for the daily visits of his gaoler. The gaoler for him becomes a timepiece. If shut up in the dungeon with sufficient food and no light or window, so that no one visited his cell he would not know whether a week or a year had passed. Of course, if he had a lamp the burning of the lamp would mark the passing of time

A Lamp in a Dungeon

If in the dungeon there were an oil lamp burning which had to be refilled from time to time that would give a means of measuring Time. But if the lamp were so placed that the oil was automatically supplied to it from outside so that it always remained at the same level in the lamp and the lamp went on burning then there would be no way of measuring Time.

Without movement it is evident therefore that there could be no Time. The old writer who said "One day is with the Lord as a thousand years and a thousand years as one day" had some idea of this great truth.

Killing Time

It is strange what misconceptions people have about Time, and how little they really understand its nature. To the majority indeed it is merely the ticking of a clock or the moving of its hands and yet all in some way realise dimly that it is connected with the passing of things. When there is little to do people talk of "killing time," which certainly shows that they have some idea that it has a connection with movement.

Seeing what a vital part Time plays in our lives how important it is that we should use it aright! If the things we do are good things we shall be able to look back with satisfaction on the passing of the Time, and feel that although it has seemed to go quickly it has not been misspent.

THOUSANDS OF TONS OF SNOW FALL ON ENGLAND

We do not often get heavy falls of snow in England, and the weight of water that a snowfall brings varies greatly. Sometimes it takes six inches of snow to make one inch of water, and at other times the snow is so light that it takes thirty inches to make an inch of water. One inch of rain is equal to 101 tons of water on every acre of land, and three inches of snow on the square mile of Kent shown here, means something like 30,000 tons of water. We should hardly think this by looking at the picture

Of course, far more snow falls in Switzerland than in England, as we can see from this photograph of a normal winter landscape taken at Adelboden. Sometimes in a single day or night a couple of million tons of snow fall upon Switzerland. It is interesting to know that snow, though solid, nevertheless evaporates slowly, but, of course, the rate of evaporation is far less than the rate at which it falls

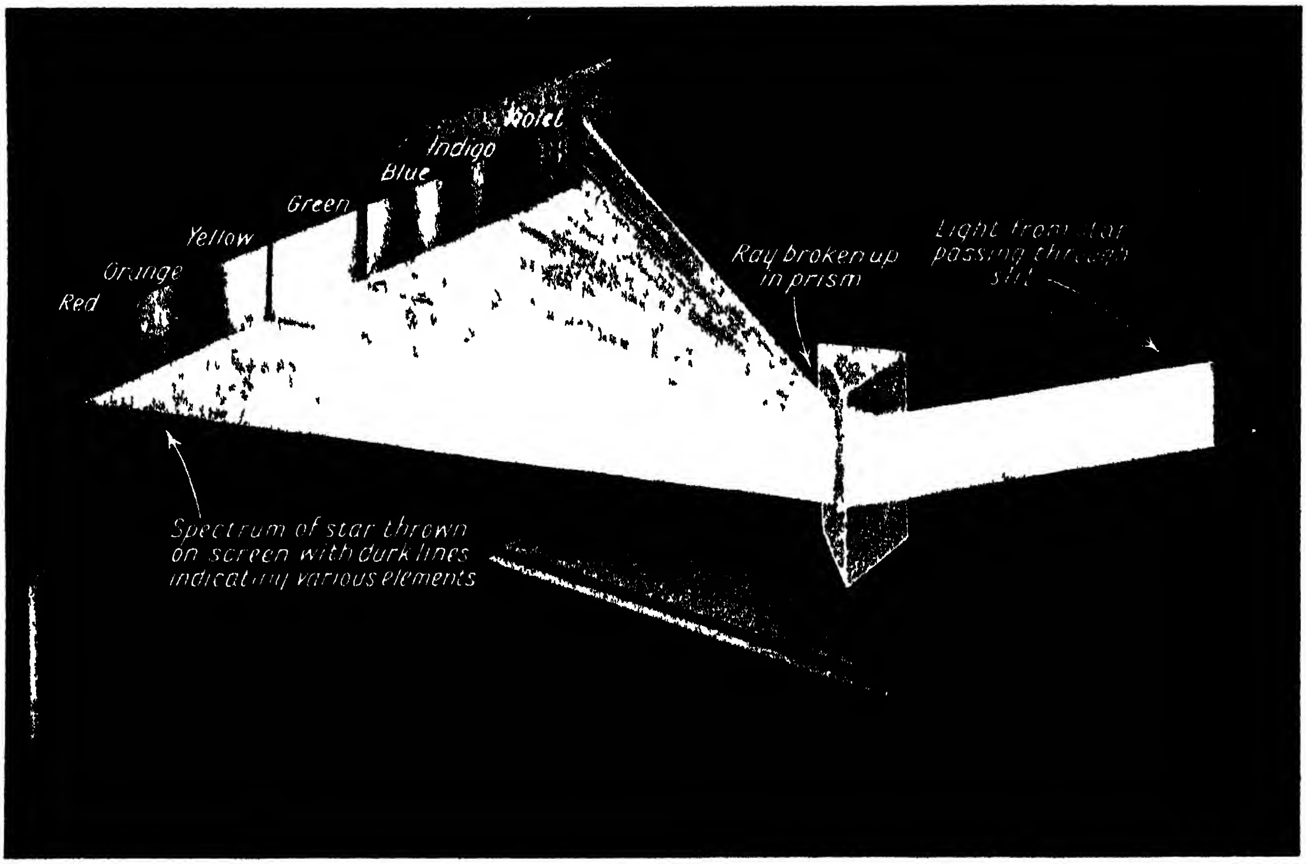
WHAT ENGLAND WAS LIKE 2,000 YEARS AGO

It has been said that God made the country but man made the town, and in a sense this is true. This photograph, taken by an airman as he flew over the Amazon Forest in South America, shows what a vast untouched forest country looks like when seen from above. The trees are closely massed together, and the Amazon River is seen flowing on its course to the sea. Two thousand years ago a large part of England was covered with forest, and would have looked like this if seen from the air. As man multiplied and found it necessary to grow food, the forests were cleared, and now fields of corn and other food plants have taken the place of the trees. The Amazon Forest, which begins near the Atlantic with a width of 200 miles, stretches almost across the continent, growing wider as it goes

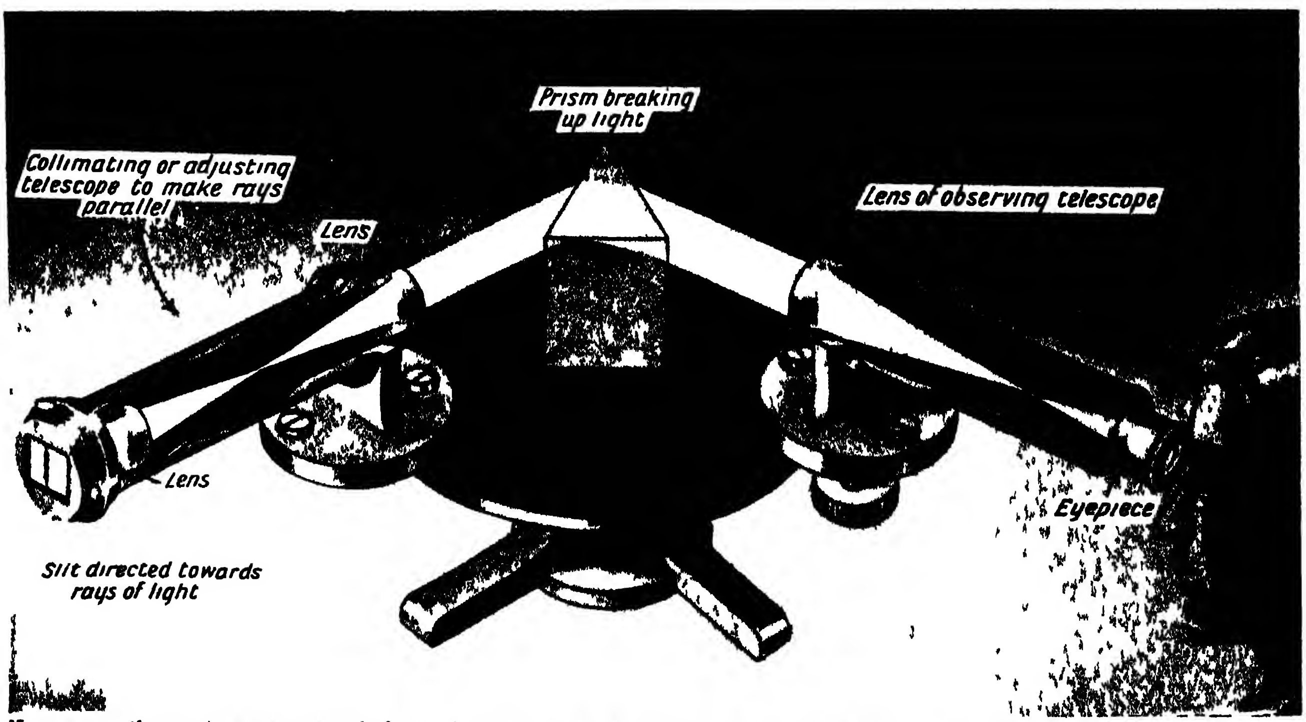
HOW MAN HAS CHANGED THE FACE OF ENGLAND

Very little of the original forest that once covered England has survived The greater part of the country is now farmland and shows a pattern of vari-coloured fields Other areas have been covered with sprawling industrial cities and are a confusion of railway junctions, smoking factories and slag heaps The above aerial view of Halifax in Yorkshire shows how completely man and his industries can ravage the face of the countryside Compare this picture with the one on the opposite page and you get a striking object lesson in how man is altering the world in which he lives All over Great Britain are scars of brick, mortar and concrete, proving how man is becoming more and more an industrial town-dweller and altering the countryside in the process

THE PRISM THAT TELLS US WHAT THE SUN IS MADE OF



One of the greatest of all scientific discoveries took place when Sir Isaac Newton let sunshine into a dark room through a small hole and caused the light to fall on a prism To his surprise, instead of getting a white image on a screen he saw a band of colour, and realised that sunlight was made up of seven colours It was the beginning of the great science of spectroscopy, or the analysis of light by means of the spectroscope, an instrument containing a prism or series of prisms Later it was found that the light from different elements produced lines on the band of colour always in the same relative positions and now, by means of the spectroscope, we can analyse the light of the sun or a star and tell what these bodies are made of Helium was first found in the sun by the spectroscope



Here we see the spectroscope in simple form The light to be examined comes through a slit, to a collimator or telescope, so arranged as to pass on a parallel pencil of rays to a prism Here the light is broken up into its colours and falls on the object glass of another telescope through which the observer looks An image of the spectrum forms at a focus in the telescope and the eyepiece magnifies it

THE MOST MARVELLOUS OF INSTRUMENTS

Man has made many marvellous instruments which have helped him to discover a great deal about the universe in which he lives. But who would have thought that he would ever have been able to find out what the Sun and the stars were made of? Yet he has done this by means of the most wonderful of all instruments, the spectroscope, the essential part of which is a little glass prism. By means of the spectroscope man has even found substances in the Sun before he has found them on the Earth, a notable example being helium. Here we read about this greatest of all wonders in modern science

WHO would have dreamt that man could ever have discovered what the Sun is made of? That great globe of fire, from which we derive our light and heat, is 93 million miles away from us and to think of finding out what particular substances there are in the Sun would have seemed to the scientists of a hundred years ago quite beyond the reach of human possibility

Yet the great discovery has been made In fact, some of the elements have been found in the Sun before being discovered on the Earth helium was first found in the Sun and that is why it was given its name which comes from the Greek word for Sun helios Then after this substance had been found in the Sun men of science reasoned that it must also exist on the Earth and they hunted here till they found it Now they can fill an airship with helium gas

Reaching to the Stars

But we have not yet exhausted the realm of man's ingenuity for he can reach out much farther than the Sun and can tell us what substances there are in stars so far away that we cannot reckon their distance in miles, but have to speak of them as being so many hundreds of thousands of light years away A light year is the distance a ray of light, speeding at 186 000 miles a second, can travel in a year

How is this great wonder performed? Well, it is all done by means of a little instrument known as a spectroscope The name comes from two Greek words which together mean "to look at an apparition" It is really one of the most marvellous instruments that have ever been invented, and when it was first made no one had any idea of the wonders it could perform

It is really an apparatus for breaking up light into its various colours We know that when white light passes through a prism or a bevelled edge of glass, or even a drop of water, it is broken up into seven colours, which always appear in the same order, namely, violet, indigo, blue, green, yellow, orange and red These colours which appear in a band are known as the spectrum and a very beautiful 'apparition' they form The rainbow, as we read elsewhere in this book is only a spectrum brought about by the sunlight being broken up and reflected from countless drops of rain

When a beam of light is passed through a prism it is broken up into the colours of which it is composed This is known as dispersion, and the beam of light is called the spectrum The greater the dispersion the longer will be the spectrum, and so when a very long spectrum is wanted it is usual to use a number of prisms, as shown here. The light passes through several prisms one after the other, the dispersion becoming greater at each, till at last, when the band of light passes into the observing telescope on the right, it is much drawn out In practice the prisms are put closer together than shown here

Sir Isaac Newton who did so many wonderful things, was the first man to examine in a scientific way the results of passing light through a prism He admitted sunlight through a small hole in a window shutter and allowed the beam to pass through a glass prism. The result was that on the opposite wall an image of the spectrum was thrown with the violet colour farthest from the original direction of the light and the red at the other end of the band It was Newton who gave the name of 'spectrum' to the band of colour

It must be understood and we can test it for ourselves that there is no definite dividing line between the colours They blend into one another almost imperceptibly so that it is impossible to say where one begins and the other ends It is often difficult to distinguish indigo from the blue and violet

The prism thus shows us that white light is made up of a number of colours, and that the position of each in the spectrum depends upon the angle at which it is bent by the prism It is rather interesting to note that if the light after passing through one prism and being broken up into colours is then allowed to pass through another prism placed the reverse way the colours will be blended once more into a beam of white light

Catching and Breaking Light

The spectroscope the wonderful instrument which we are considering is an apparatus with a prism and telescopes so that the light from the Sun, or a star, can be conveniently caught broken up and examined

Many kinds of spectroscope are made some indeed are very simple, and can be carried in the pocket Others are more elaborate, and it is with these latter that the wonderful work of examining the Sun and stars is carried out

It is white light which gives a continuous spectrum of the seven colours and we can get this not only from sunlight but from any incandescent solid such as the white hot carbon filament of an electric lamp, or of a limelight or from an ordinary gas or candle flame in which the light giving particles are really bits of incandescent solid carbon

If now we take a spectrum of a glowing gas or vapour it is quite different There is no broad band of colour as in the cases mentioned instead we see merely a few bright lines of different colours in certain positions with the spaces between

them quite dark. If for instance we sprinkle a little salt on the wick of a spirit lamp the flame, which was almost colourless, becomes very yellow. This is the sodium of the salt burning, and it always gives this same yellow colour.

Now if this flame be examined with a spectroscope there is never any violet, indigo, blue, green, orange or red, but merely two bright yellow lines close together. The reason why there is no continuous band of colour is that the atoms of sodium vapour, being in a state of agitation, produce vibrations which in their turn give waves always of the same length, and those waves are the waves that become visible as yellow light.

Let us carry our experiments further. Let us place behind the spirit lamp on which we sprinkle the salt an incandescent limelight, and between the two lights a screen. We examine the yellow sodium flame first of all through the spectroscope and get, as already explained, two bright yellow lines with all the rest dark. Now we remove the screen and at once the spectrum consists of the band of colours with two dark lines in exactly the position where the two bright yellow lines were previously. What is the explanation of this?

Lines in the Spectrum

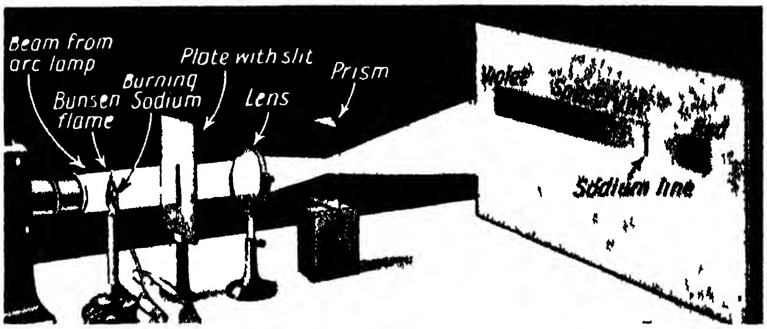
Well, the continuous coloured spectrum is the broken up light of the incandescent lime and the two dark lines are the spectrum of the burning sodium in front. They are not really dark, but only seem dark by contrast with the brilliant continuous spectrum. The burning sodium is much cooler than the incandescent lime and the cooler sodium vapour absorbs from the continuous spectrum of the lime those rays which correspond to its own spectrum.

Experiments have shown that every chemical element when heated sufficiently to vaporise and every gas heated to incandescence has its own characteristic spectrum. This consists of certain bright lines which belong to it alone, and they always appear in exactly the same position in the spectrum. No two elements have the same lines, nor any lines in common.

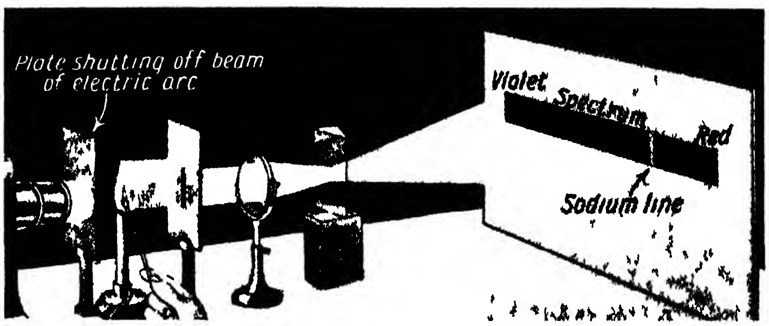
It is this fact which enables us to tell what elements there are in the Sun and the stars. When sunlight is examined through a very good spectroscope there are always a large number of dark lines in various parts of it. It was not understood at first what these were, but now we know that they are the spectra of various elements which are in a state of vapour in the Sun's outer envelope. The white light from the main body of the Sun gives a continuous spectrum with the colours violet, indigo, blue, green, yellow, orange and red, but this light has to pass through the outer envelope of glowing vapour which surrounds the Sun. And so we get the spectra of the different elements in that vapour showing on the band of colours.

By comparing the position of these different lines with the spectra of light from different elements we can tell what elements there are in the Sun's envelope. Already about forty elements have been discovered in this way, and similarly the spectra of various stars have shown us that many elements found on the Earth also exist in these distant suns, for suns they really are.

It is the spectroscope that has told us practically all we know of the physical constitution of our Sun and of the stars. It was a Bavarian optician named Joseph von Fraunhofer who first noticed that certain dark lines in the Sun's spectrum coincided in position with the bright lines of the spectra of various artificial flames, and started science on the highroad to its marvellous discoveries about the Sun and distant stars.



Here is a white beam from an electric arc lamp which, passing through a slit in a plate, is converged by a lens so as to fall upon a prism, that breaks it up into the seven colours of which it is composed. The band of colour is called a spectrum. Between the lantern from which the beam shines and the slit is a Bunsen flame, and in this is burned a small piece of the metal sodium, with the result that on the spectrum a dark line appears in the yellow part



In this picture the light from the electric arc has been shut off by a plate and now only the light from the sodium flame can pass through the slit on to the prism. The result is now a dark ground with only a bright yellow line in the place where the dark line appeared previously. The line in the upper picture was not really black, it only appeared so in contrast with the spectrum of white light. When we see the spectrum of the sodium flame alone it appears merely as a yellow line on a dark ground. It always appears in the same position and so when we find it in a spectrum of sunlight we know there is sodium in the Sun. In this picture we show a dark band to correspond with the spectrum of the first picture, but in actual practice the whole screen would be dark. The sodium line also really consists of two very fine lines close together

The spectroscope tells us much more even than the mere composition of the distant suns. It is wonderful enough that we should be able by its aid to learn more about a star a million million miles away than about the crust of the Earth five miles down. But we can also tell by the spectroscope whether a star is an old star or a youngster, and whether it is moving away from us or toward us, and also the speed at which it is moving. Star motions as small as one fifth of a mile a second can be detected by this most marvellous of all instruments.

The Displaced Lines

When the spectrum of a star is photographed it is compared with a spectrum of iron vapour, the particular lines of the iron spectrum forming a standard of reference. If we are travelling towards something which is giving out light waves in our direction, we meet more light waves per second than if we are stationary, and the effect is to shorten the wave lengths. On the other hand if we are receding the wave lengths become greater. When a star whose spectrum we photograph is moving towards us every wave length of its light appears shorter than it would do if Earth and star were stationary, and this has the effect of displacing its iron lines towards the violet end of the spectrum. The reverse is true if the star is receding. The displacement is then towards the red end. The amount of displacement indicates the speed of the star's movement.

THE MARVELLOUS ROMANCE OF THE EEL

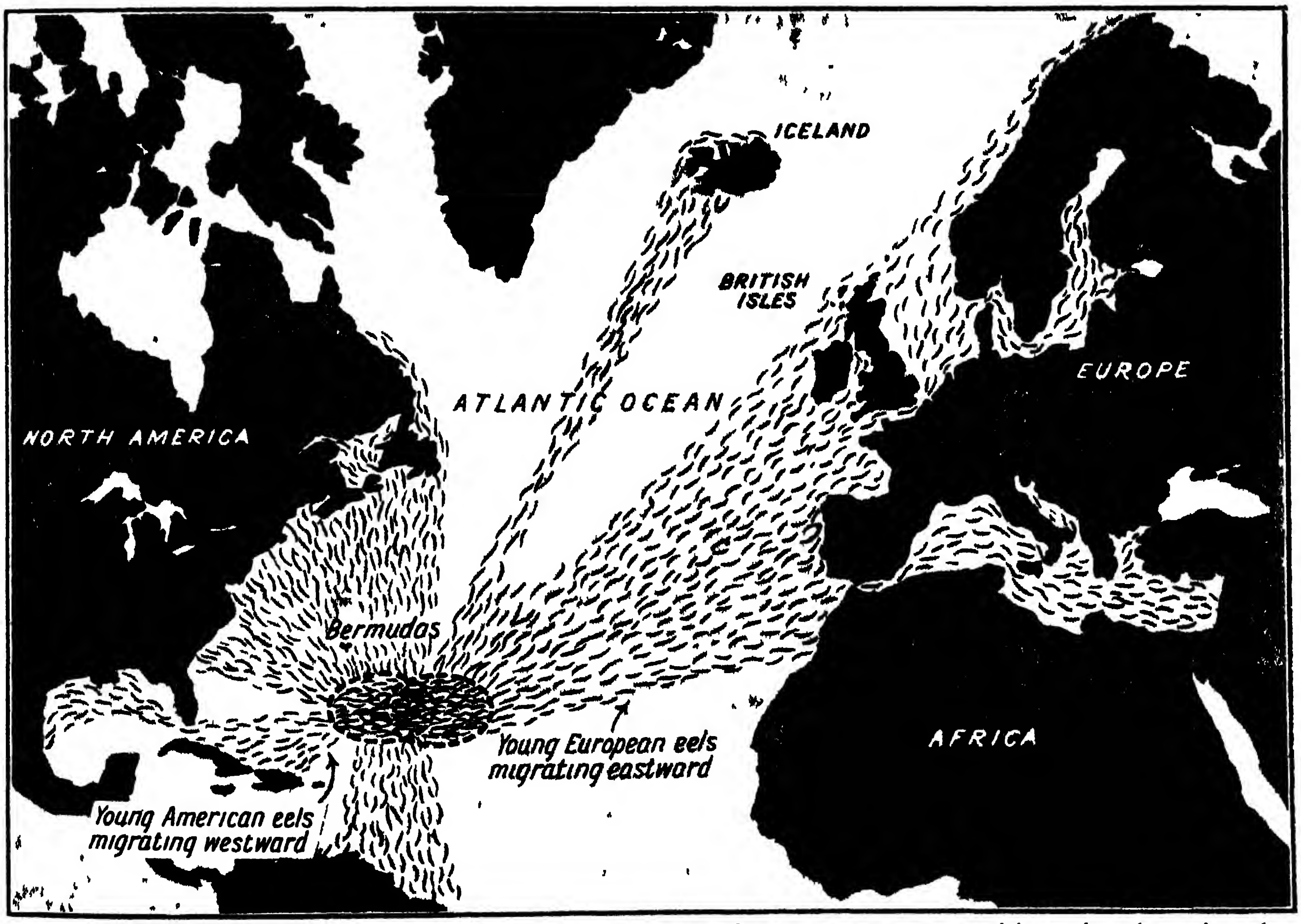
The story of the common eel which we so often see in fish shops is a very remarkable romance which it has taken men of science long years to discover. The eel is, of course, one of our fresh-water fishes, but it is not born in river or lake or pond, but in the depths of the sea, far away in the Atlantic. How it makes its way across the ocean and up the rivers of Europe and then later finds its way back forms one of the most remarkable of all natural history stories. The facts of this wonderful romance can be read in these pages

THE life stories of many living creatures are romances more wonderful than any imaginary stories that can be made up by even the most inventive writers. We could not believe them if the evidence did not make it impossible to disbelieve. Who, for instance, could ever have invented such an amazing story as that of the life of the common eel which we catch in rivers and lakes and find in the fishmonger's shop?

Here is a fish that looks like a snake whose scales are out of sight embedded in its skin and whose home is the fresh inland waters. If ever there was a fresh water fish we should say it was the common eel. But every eel we see was born away out in the Atlantic Ocean, hundreds of miles from England and half a mile down below the surface, where the weight of water is so enormous that even an engine or a motor car would be crushed flat.

The romantic life story of the eel has been discovered by men of science only in recent years and it has had to be pieced together bit by bit. What are the facts about this strange fish? Well, here is the story.

No egg or spawn of the eel has ever been found in a river or pond, and no eels are hatched out in the place where they habitually live. At a certain season of the year eels, like birds and other creatures, desire to become parents. They get restless, and then instead of laying their spawn in their fresh water homes they make their way from inland waters by way of damp ditches and even across the meadows and roads, to the streams and rivers and so at last to the sea, and swim away across the Atlantic to the neighbourhood of the Bermudas.



This picture-map illustrates a most remarkable fact about the eel. Every eel that we see in our rivers, lakes and ponds was born deep down in the Atlantic in the neighbourhood of the Bermudas, and made its way across the ocean and up the rivers of England. Its parents had, a year or two before, travelled from some lake or river in Europe, and often across country by way of damp ditches, to the sea, where they produced a family of young eels. All the eels found in Europe come from the depths of the ocean. American eels, which are a different species, also breed near the Bermudas, and they all make their way westward, and we never find American eels travelling eastward or European eels travelling westward

Even the eels that are kept in aquariums and private ponds climb out and try to get away to the sea. The owner of an aquarium who kept eels inside a building found morning after morning that they had left the aquarium and tried to get out of the room where it was situated. They were put back, but the next day the restless creatures again left their watery home, and they remained restless for weeks because they could not follow their fellows away to the Bermudas.

Children Unlike Their Parents

At the season when this happens eels change their appearance and their skins become silvery. Indeed, it used to be thought that these silvery eels were a different species from the ordinary one, but we know better now.

Having reached mid-Atlantic the eels disappear and are never seen again. They evidently go down to great depths to lay their spawn or eggs. In due course the little eels are hatched out, but they are not a bit like their parents. They are tiny flat fish, and are so different that up to a few years ago men of science thought they were an entirely different creature, and named them leptocephalus, a word which means small or narrow skulled.

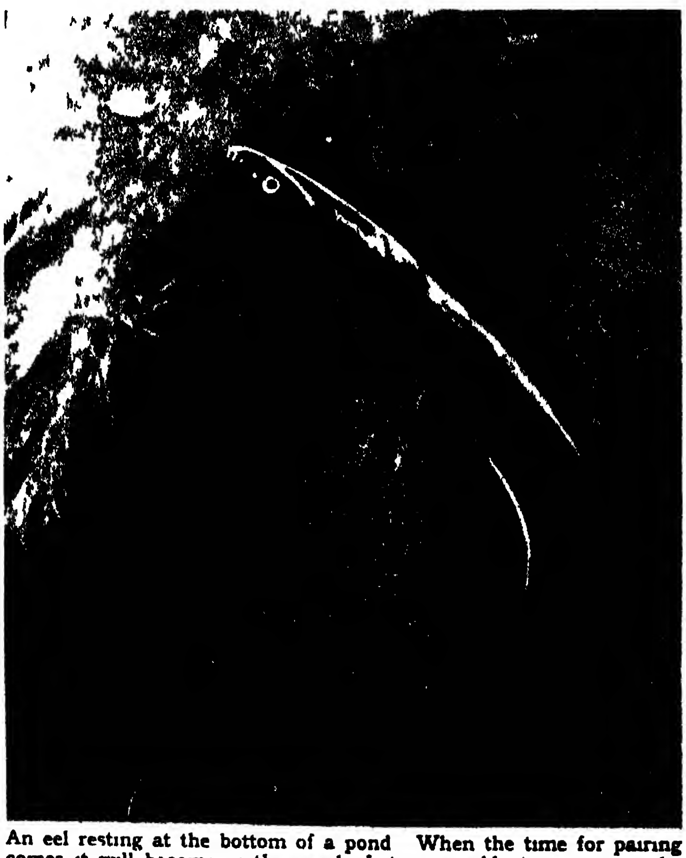
These young eels are born flat because this form is suited to the situation in which they start their lives. The pressure of water resting upon them is equal to many tons. Gradually they rise to the surface and then from their birthplace near the Bermudas they slowly make their way across the Atlantic to Europe. As they do so they increase in size and change their form till they are miniature eels.

It takes them about two years to reach the river mouths of Britain and Europe. Then they make their way in millions up these rivers, and their arrival is known as the eel fare, they themselves being called elvers. Fishermen catch them in nets by the hundred thousand. Cooked and eaten at this stage they are regarded as a great delicacy. Generally they are fried and eaten with bacon and eggs.

Great Travellers

But thousands of other young eels are transferred in vessels to ponds and lakes and other inland waters. Those that are not caught travel up the rivers and through the tributary streams till they are found all over the country. This is true of all the lands whose rivers communicate with the Atlantic Ocean.

An eel rising in the water for food



An eel resting at the bottom of a pond. When the time for pairing comes it will become restless and, if it is possible to escape, make its way out of the pond and across country to the sea

Some eels travel overland to enclosed waters, and they have been found even in the Swiss lakes 3,000 feet above sea level, to which they have travelled by way of rivers, streams and damp grasslands.

It all seems quite incredible, but the evidence for the truth of the story is beyond doubt. To enable it to cross dry land on its way to or from the Atlantic the eel has a wonderful development of the head which enables it to store up water so that it can breathe through its gills as it travels overland.

Mothers Grow Bigger than Fathers

An eel is a greedy creature, and the female of the species is bigger and greedier and fiercer than the male. While the father eel rarely exceeds three feet in length the mother is often double that size, and some common eels have been found weighing as much as 25 pounds.

The eel will eat almost anything, frogs, carrion and so on, and large eels have been known to drag down under water ducklings and moorhen chicks from the pond on which they were floating and devour them. Sometimes a large eel that has been speared by a heron winds itself round the bird's neck and both fish and bird die together.

Wonderfully adapted to its peculiar mode of life, the eel's snake-like form and slimy skin enable it to worm its way through reeds and grass and mud, and a good supply of slimy glands gives it a useful slipperiness. The stiff scales of the ordinary fish would be a great handicap to the eel. Hence the burying of the scales in the smooth slippery skin.

A Prodigy of the Depths

But the whole romance of the eel has not yet been told. Out in the Atlantic Ocean where the European eels breed, eels from the American Continent also lay their eggs and have their young, and yet, marvellous to relate, while the young of the European eels always travel eastward, those of the American eels invariably travel westward. The two species breed together in the same water, and yet the American eels never travel eastward, nor do the European eels ever travel westward. Science cannot explain to us why this should be.

Sir Ray Lankester has very aptly summed up the romance of the eel in these words: "Who would ever have imagined, when he caught a wriggling eel with a hook and worm thrown into some stagnant pool in

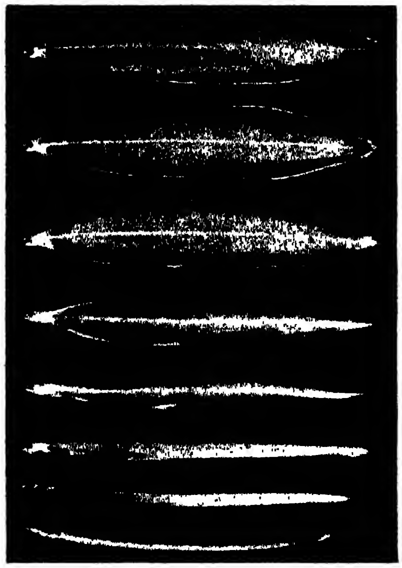
the Midlands, that the muddy creature was some five or six years ago living as a glass-like leaf-shaped prodigy in the Atlantic depths? Who would have dreamed that it has come all that long journey by its own efforts, and would probably, if it had not been hooked, have wriggled one summer's night out of the pond, across wet meadows, into a ditch, and so to the river, and back to the sea, to the far-away orgy in the dark, salt waters of the ocean floor, to the consummation of its own life and its strange, mysterious ending?"

Eels Were Always a Delicacy

The eel has formed a table delicacy from the times of the Ancient Greeks, some of whom described it as "the Helen of the dinner table." They even made it a divinity, and spoke of "those natives of the stream, holy eels." The Romans also delighted in eels, and kept them in marble ponds so that they could have them for the table whenever they wished.

To the Jews, however, the eel was a prohibited fish, as it was supposed to be without scales. Of course, this idea has been proved by modern science to be wrong. The eel has scales, although they are very small and are buried in the skin.

In England, in olden times, the eel was a very important article of diet, for people relied much more then upon fresh water fish than they do now. Every monastery, of course, had its fish pond, if it did not happen to be built on or near a river. The eels were often salted and kept for winter use when food was scarce.



The development of young eels from the leptocephalus stage, when it is flat, to the more general cylindrical form. These pictures are magnified

How popular the eel was is shown by the fact that so many places are named after it. The city of Ely, for example, is said to be so called because the local rents were paid in eels, and the name of the other Ely, near Cardiff, is said to have the same origin. Elmore, on the Severn, received its name owing to the large number of eels that were captured there, and we all know the name of Eel-pie Island at Richmond.

Eels are still used as food by most European countries, the most popular being conger and fresh-water eels. The meat is nourishing and delicate when properly cooked, though some people find the flesh too oily and the fine bones too difficult to remove. Before the First World War a large catching depot at the mouth of the Severn exported 250 million elvers to Germany every year.

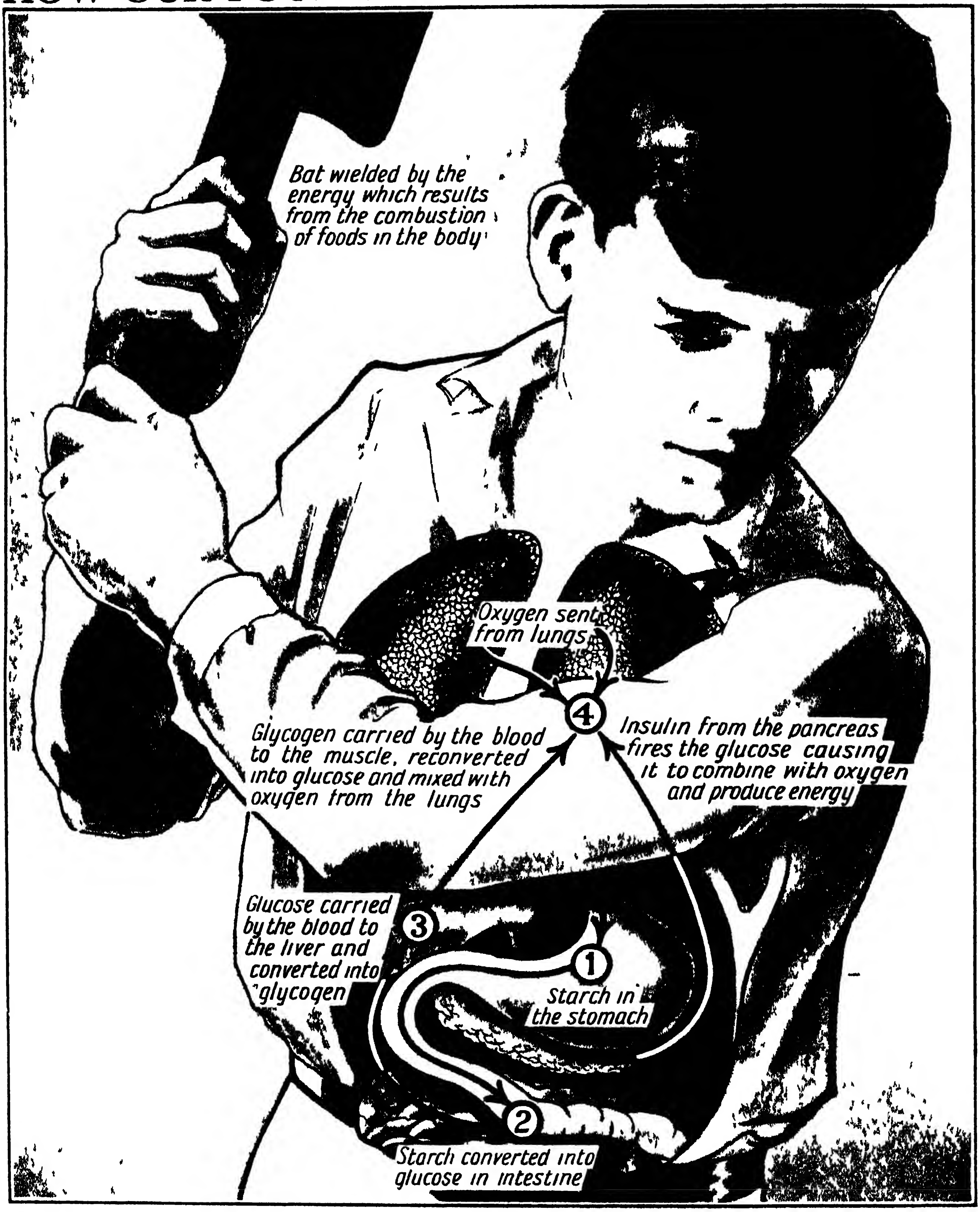
Native to warm seas are the eels called morays, many of which are brilliantly coloured. The muraena, so highly-prized by the Romans, is a member of this group.

The so-called electric eel, which is illustrated and described in page 228 of volume 1 of this book, is not an eel at all but is a species of gymnotid related to the carps and catfish.

A GIANT LOBSTER CAPTURES HIS DINNER

The lobster, which is a blackish-green colour when alive, and only turns red after boiling owing to chemical changes brought about by heat, is a quarrelsome creature and loves to fight. Often when the lobster pots or traps are taken from the water some of the lobsters have lost their big claws by fighting. But unlike ourselves when we lose an arm, a crustacean can grow a new limb. Lobsters, like all their relatives, are scavengers and will eat anything in the flesh line, preferring it decomposed. Here we see a lobster about to devour a crab

HOW OUR FOOD STRENGTHENS OUR MUSCLES



It is the food we eat that gives strength to our muscles and helps us to do such things as kick a football or hit a cricket ball with a bat. In this picture we see how it is that the food strengthens the muscles. The carbohydrates which we take into our mouths pass to the stomach and intestine, where the starch is converted into glucose, and is then absorbed and carried by the blood to the liver. There it is converted into glycogen and stored up for use. As required it is carried by the blood to the muscles, where it is changed back into glucose and mixed with oxygen from the lungs. It is now like the petrol in the motor engine, a useful fuel only waiting to be fired to produce energy. The firing is done by insulin from the pancreas, which causes the glucose to combine with the oxygen and produce the energy which helps us to kick the ball or use the bat or do any other work requiring strength.

THE POWER OF A GROWING PLANT

HOW ROOTS AND STEMS OVERCOME ALL DIFFICULTIES

THE mystery and power of growth in plants is a constant wonder to those who will take the trouble to think. Let us consider, for example, the astonishing variety of plant life that comes out of the earth.

Here we have a dainty little harebell and there a giant redwood tree rising to a height of 320 feet, with a trunk circumference of more than a hundred feet. Here is a beautiful and fragrant rose, a delight to the eye and a joy because of its scent, and there is a stinkhorn fungus smelling like rotten meat and offending our nose a score of yards before we come upon it.

The Amazing Variety of Plant Life

Here is a luscious peach with its delicate colour enhanced by the bloom, and there is a coarse, unattractive looking turnip or swede. So we might go on. Indeed, we need not travel outside our own garden to find evidence of the amazing variety of plant life.

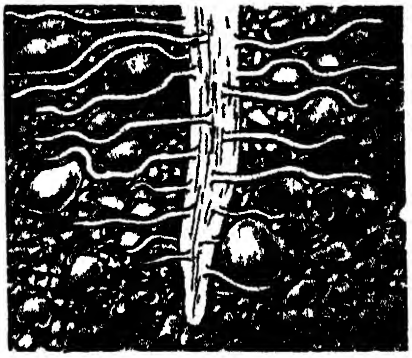
Yet the material for all these giant growths, or delicate flowers, or useful or luscious fruits is drawn from the soil. The Great Master, referring to the spread of goodness in the world, used the most apt of all illustrations when he likened it to the mystery of plant growth. He said: "... as if a man should cast seed into the ground, and should sleep, and rise night and day, and the seed should spring and grow up, he knoweth not how. For the earth bringeth forth fruit of herself; first the blade, then the ear, after that the full corn in the ear."

The Mystery of Growth

How do the plants grow? How do they obtain the material for their increase? What is their source of power to overcome obstacles and meet with success in the world? If we could answer all these questions satisfactorily, we should have solved the mystery of life. As Tennyson said:

> Flower in the crannied wall,
> I pluck you out of the crannies,
> I hold you here, root and all, in my hand,
> Little flower—but *if* I could understand
> What you are, root and all, and all in all,
> I should know what God and man is.

Science, however, has taught us something about growth. We know that the increase in size of a plant or, for that matter, of that of an animal, comes about by the cells of which the plant or body is made up multiplying. Each cell divides, and then the parts become complete cells, and so the growth goes on till maturity is reached.



The tip of the root of a seedling maple tree magnified, showing how slender hair-like tongues are sent out and push their way between the particles of sand and earth to suck up food for the plant's nourishment and growth

In order that a plant may grow, five conditions are necessary. In the first place it must have moisture; then, secondly, there must be a favourable temperature; in the third place the plant requires air; then, fourthly, it needs light; and lastly, a constant supply of food is essential. If any one of these conditions is absent the plant cannot possibly show healthy growth.

All Things Come Out of the Earth

First of all let us think how the plant needs water in order to grow. It draws its moisture from the soil, and a writer has well said: "From the soil all things come, and into it all things at last return, and yet it is always new and fresh and clean, and always ready for new generations. This soft thin crust of the Earth, so infinitesimally thin that it cannot be shown in proper scale on any globe or chart, supports all the countless myriads of men and animals and plants, and has supported them for countless cycles, and will yet support them for other countless cycles."

Moisture Essential

The soil must have moisture if the plant is to live and grow. Sometimes the moisture is obtained naturally from rainfall or rivers or streams, and sometimes in dry and arid regions it is supplied by artificial irrigation. The plant does a good deal to help itself. It will send its roots down many feet and in all directions searching for moisture, and in some cases, as in that of the cactus, it will store up supplies of water in its leaves, which become big and fleshy in order to retain the moisture.

Any living plant is largely made up of water. Generally more than three-quarters of its weight consist of water, and large quantities must pass through the plant all the time it is living in order that the food solution in the soil may be carried to the leaves.

The water travels up through the roots and is passed off into the air through the leaves and

A gooseberry bush with its roots excavated from the earth in which it was grown. The enormous length of the roots can be seen from the height of the boy standing at the side. The lengths which roots attain in their search for water are enormous. The combined length of the root of one blade of wheat has been found to exceed a third of a mile, and the American mesquite sends its roots down 40 feet into the ground

growing shoots. Experiments have shown that for each ton of dry grain produced from the soil from 300 to 500 tons of water must have been taken in from the soil by the growing plants.

The plant if it is to grow must have heat, but the temperature must be within certain limits if the plant is to be healthy. When the soil is below a certain temperature the life processes of the plant are more or less suspended, but above that minimum the plant grows and develops successfully until a certain degree is reached, and then with too much heat the life processes again cease. Maize, for example, will only germinate at a temperature of 48 degrees Fahrenheit or more, and it ceases to germinate above 93 degrees.

There are three sources from which the soil derives its heat. One is the internal heat of the Earth, but how far this affects the temperature near the surface is unknown. In any case it must be quite small. Then decaying organic matter in the form of manure heats the soil to some extent. But the most important source of heat is the sun. This shines upon the surface of the ground and the heat passes downward by conduction.

That air is necessary to the growth of plants can be proved by a simple experiment. We take two wide-mouthed bottles and in the bottom of each place some wet blotting paper, pouring in water to cover the paper.

Now we fill both bottles with peas or beans that have been previously soaked in water for 24 hours. Into the neck of one bottle we place a tightly-fitting cork and leave the other bottle open. As the water evaporates from day to day we pour in more to make up for the loss. If we put both bottles in a warm place we shall find after a short time that while in the case of the corked bottle, the peas or beans remain as they were, in the other bottle they sprout and begin to grow.

In some way which is not understood by scientists the energy of the seed is set free by the action of the oxygen in the air. The oxygen which the plant uses acts in the same way as it does upon a fire. Heat is released and carbon dioxide is produced.

While in vegetation of a certain kind light is not necessary to germination and growth it is essential for the healthy development of green plants. Without it they become stunted.

Finally the plant must feed or it will not grow any more than a boy or girl will grow if starved.

Given all these suitable conditions, the power of growth is amazing. Nothing can resist it. The roots develop and penetrate far into the ground in search of food and moisture, while that part of the plant which is above ground develops and becomes strong in spite of all obstacles. So persistent is the growth that even an apparently feeble plant can do marvels.

A growing mushroom or toadstool has been known to lift a paving stone that was in the way. A sapling tree that has developed from a seed fallen into a grave has grown bigger and bigger till it has split the stone tomb above it. A young larch tree growing in a fissure of a big boulder has forced up a portion of the stone weighing nearly a ton and a half. The roots of a tree in the Editor's garden upheaved a massive wall till it fell, and close by a trunk of a tree grew round some heavy iron railings and absorbed them.

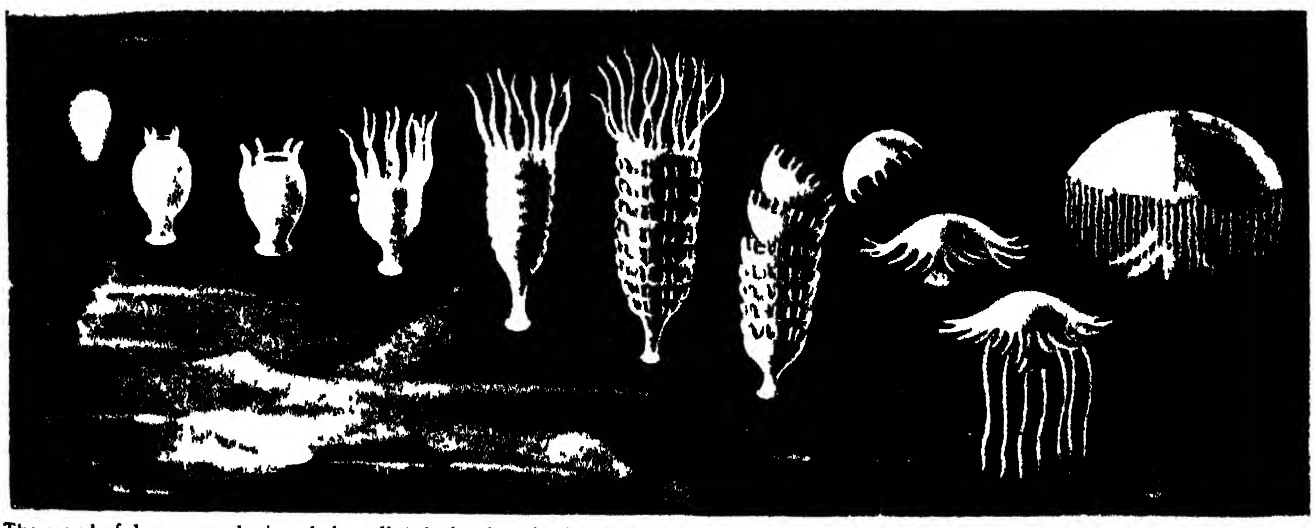
THE STRANGE STORY OF THE FAMILIAR JELLYFISH

The more we study the life stories of living creatures the more strange and wonderful they seem. Some of the most remarkable life stories are those of familiar creatures which do not at first glance seem very interesting.

Take for instance the jellyfish which extraordinary power of developing into not one jellyfish but many. It reproduces itself by buds and shoots growing on the surface of its body.

It floats for a time, then fixes itself to a rock, and after changing till it appears like a number of saucers piled to hatch out into young jellyfishes.

The jellyfish belongs to a family known as the Medusae. Some are very small indeed and others very large. One of the latter seen on the shore near Bombay is said to have weighed several tons, yet having no bones or shell, it



The wonderful way in which a baby jellyfish develops by budding and produces a colony of jellyfishes. The floating larva is seen on the left and the fully developed jellyfish on the right, different stages being shown between

is so common round our coasts and which we see thrown up on the beach and also floating in the water. How is it born and what is its life history?

Well the picture on this page shows the development of a jellyfish from the moment when the larva is hatched from one of the eggs released by the mother jellyfish. This larva has the one upon another, it throws off disc after disc, each of which floats in the water and develops into a perfect jellyfish. One individual hatched from an egg may thus in a short time develop into a large colony.

In the course of time these jellyfishes become parents. They in turn produce eggs which are later released disappeared in the course of nine months, to the astonishment of the native fishermen, who watched it in the hope of being able to obtain bones or other remains that might prove useful.

At the other extreme certain Medusae found off the coast of Greenland are so small that a wineglass of water can hold 3,000 of them.

ROMANCE oF BRITISH HISTORY

THE TALE OF AN IMPUDENT IMPOSTOR

King Henry the Seventh did not find it easy to hold his throne. He had enemies in other countries, who were only too glad to support impostors and help them in their efforts to seize the crown. The most formidable of these impostors was Perkin Warbeck, and here we read the story of his attempted usurpation

THERE is no doubt that the clemency and moderation of Henry the Seventh after the quelling of the Lambert Simnel rebellion impressed the people of England and made them much less ready to take up arms against him in future.

How wise he had been was soon proved, for only five years later another impostor arose, this time a much more formidable one than Simple Simnel had been. In this case, as in the previous one, Margaret of Burgundy, Edward the Fourth's sister who hated Henry, played a leading part. Indeed, if she herself were not the first to suggest the imposture she, at any rate, inspired and trained the impostor.

A Clever Counterfeit

Francis Bacon, who wrote the history of Henry the Seventh, tells us that "the King began again to be haunted with spirits, by the magic and curious arts of the Lady Margaret; who raised up the ghost of Richard, Duke of York, second son of King Edward the Fourth, to walk and vex the King."

He adds: "This was a finer counterfeit stone than Lambert Simnel, better done, and worn upon greater hands; being graced after with the wearing of a King of France, and a King of Scotland, not of a Duchess of Burgundy only. And for Simnel, there was not much in him more than that he was a handsome boy, and did not shame his robes. But this youth of whom we are now to speak was such a mercurial as the like hath seldom been known, and could make his own part if at any time he chanced to be out."

It was part of the Duchess of Burgundy's policy to keep alive on all possible occasions the idea that little Richard of York, the second son of Edward the Fourth, had not really been murdered in the Tower of London at all! She pretended that those who had destroyed the elder brother, Edward the Fifth, were stricken with remorse and compassion towards the younger, and instead of killing him set him free to seek his fortune.

Of course, the story was a foolish one, for villains such as those concerned in the murder of the little princes were not likely to be moved by pity, and certainly Richard the Third, if he did not actually see the bodies, must, at any rate, have taken the most sure and certain means of knowing that the princes were actually dead.

There are always plenty of people ready to believe a rumour, however foolish, particularly if it is in some way mixed up with a mystery, and so there were, no doubt, at that time, thousands of people, both in England and in Europe, who thought it quite likely that the little Duke of York had been saved after all. When, therefore, the Duchess of Burgundy in 1492 sent a rather plausible and attractive young man, gaily dressed in fine clothes like a prince, over to Ireland, declaring that he was her nephew, people soon flocked to him, for if it is true to-day that the mass of people love a prince, it was even truer then.

A search was made for the bodies but they could not be found

The so-called Duke of York landed at Cork, and he at once wrote a letter to the Earl of Kildare, who had helped Simnel and been forgiven by Henry the Seventh, to come to his aid and be of his party. Kildare, however, possibly because of Henry's lenient treatment of him on the previous occasion, was not so ready to dabble with rebellion as he had been before.

Apparently the young man from Flanders did not seem so English as he should have done if he were really Edward the Fourth's son, for we are told he was put in training to speak good English.

Meanwhile, over on the Continent, Margaret of Burgundy was not idle. She did all she could to gain friends for the supposed prince, and enlisted the good will of Charles the Eighth, King of France.

Honoured by a King

This monarch did not love Henry of England, and was only too glad to embrace any chance of making difficulties for him. He, therefore, through the Duchess Margaret, let the supposed prince know that he was his friend, and invited him to visit Paris.

As Bacon tells us: "The young man thought himself in Heaven now that he was invited by so great a king in so honourable a manner, and imparting unto his friends in Ireland for their encouragement how fortune called him and what hopes he had, sailed presently into France. When he was come to the Court of France, the King received him with great honour, saluted and styled him by the name of the Duke of York, lodged him and accommodated him in great state. And the better to give him the representation and the countenance of a prince, assigned him a guard for his person."

Charles, however, was not very serious in his support. All he wanted to do was to make things unpleasant for Henry, not to spend any money in helping a rival. Bacon says that "Upon the first grain of incense that was sacrificed upon the altar of peace at Boulogne, the supposed prince was 'smoked away.'" Yet the French king

would not deliver the young man up to Henry but simply warned him and dismissed him

The youth was clever enough to know that the best thing was to disappear from Charles's territory and he therefore went back to Flanders to the Duchess of Burgundy There was a pretence that the Duchess was now meeting him for the first time She pretended to sift his claims and after hearing the story of his alleged escape from the Tower of London professed to be so satisfied that he was no impostor that she feigned herself to be transported with a kind of astonishment mixed of joy and wonder at his miraculous deliverance receiving him as if he were risen from death to life and inferring that God Who had in such wonderful manner preserved him from death did likewise reserve him for some great and prosperous fortune

Francis Bacon who explains to us in detail that the youth was an impostor says that the Duchess did him all princely honour calling him always by the name of her nephew and giving him the delicate title of White Rose of England She also appointed him a guard of thirty halberdiers to attend his person

A Princely Impostor

Neither was he for his part says Bacon 'wanting either in gracious or princely air or ready or apposite answers or in contenting and caressing those who did apply themselves unto him or in pretty scorn and disdain to those who seemed to doubt of him but in all things did notably acquit himself in so much as it was generally believed as well amongst great persons as amongst the vulgar that he was indeed Duke Richard Nay himself with long and continual counterfeiting and with oft telling a lie was turned by habit almost into the thing he seemed to be and from a liar to a believer

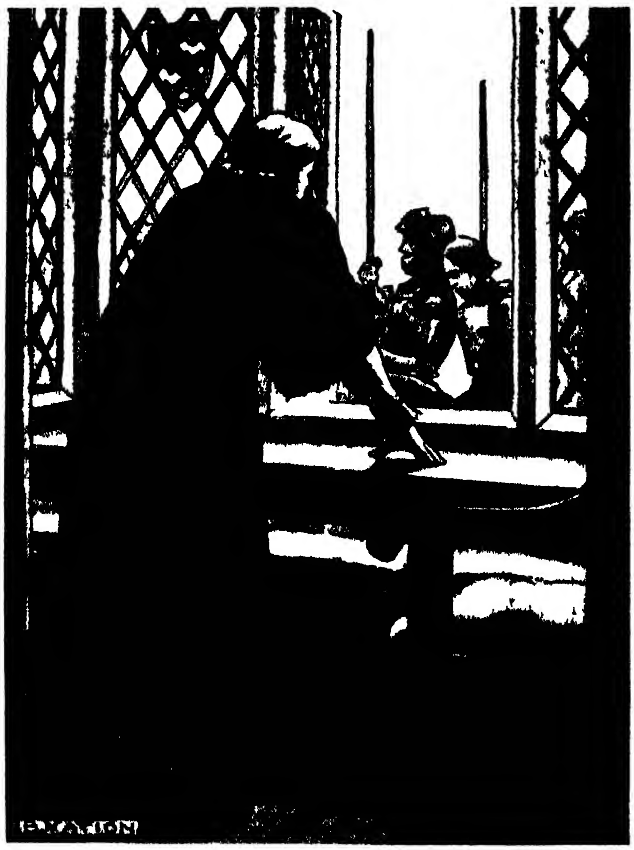
By this time the news had reached England and was being blazed all over the country that the Duke of York was surely alive and was being treated with great honour in France and Flanders

King Henry was not asleep but he was too wise and crafty to show any fear or to suggest that he was at all concerned at what was happening abroad He became busy in seeking unanswerable proof that little Richard of York was really dead

The priest who had transferred the bodies of the smothered princes from the first rude grave to consecrated ground was dead A search was made for the bodies but they could not be found It is said however that John Dighton one of the actual murderers told the King definitely that the Duke of York was actually killed He was a prisoner at the time and is said to have been forthwith set at liberty

Nimble Scouts and Spies

Henry however could not get the kind of proof he needed to convince the world He therefore decided to send over to Flanders 'divers secret and nimble scouts and spies' to see if they could find out who the claimant really was They were to spare no expense in their efforts to get at the bottom of the conspiracy and they were at the same time to point out to the youth's supporters how little chance



The king merely saw Perkin out of curiosity from a window

of success he really had so as to detach them from his cause Any English malcontents who were among the number were to be shown how weakly his enterprise and hopes were built and with how prudent and potent a king they had to deal and to reconcile them to the King with promise of pardon and good conditions of reward"

The False Prince Unmasked

Apparently these spies and scouts were successful in their mission, for we are told that as a result of their efforts the King had 'an anatomy of the impostor alive' that is, a full account of his pedigree and history The supposed prince was really a native of Tournay in Belgium the son of a converted Jew named Jehan de Werbecque sometimes known as John Osbeck The boy's name was Peter, and having been given the diminutive name of Peterkin came to be known as Perkin The name by which he has come down to us in history is Perkin Warbeck We are told that 'he was a youth of fine favour and shape but more than that he had such a crafty and bewitching fashion both to move pity and to induce belief as was like a kind of fascination and enchantment to those who saw him or heard him"

He seems to have been a kind of ne'er do well who had travelled a good deal and lived by his wits the kind of person who in these days would float a bubble company or play the confidence trick on rich strangers

Learning a Smooth Tale

Duchess Margaret, says Francis Bacon, 'thought she had now found a curious piece of marble to carve out an image of a Duke of York She kept him by her a great while but with extreme secrecy The while she instructed him by many cabinet conferences first in princely behaviour and gesture teaching him how he should keep state yet with a modest sense of his misfortunes Then she informed him of all the circumstances and particulars that concerned the person of Richard the Duke of York which he was to act and described unto him the personages lineaments and features of the King and Queen his pretended parents and of his brother sisters and divers others that were nearest him in his childhood Together with all passages some secret some common that were fit for a child's memory till the death of King Edward' She taught him, adds Bacon, to tell a smooth and likely tale warning him not to vary from it

Henry tried to get the youth driven out of Flanders by Margaret's son the Archduke Maximilian but was unsuccessful Time was passing and Perkin having won a number of English refugees to his cause decided to make a descent upon the coast of Kent We do not know how many men he had but he cast anchor off Sandwich and Deal and sent some of his warriors ashore boasting of the great force that was to follow The Kentish men, however were very cold, and noticing that there was no distinguished Englishman among Perkin's supporters, set upon those who had landed and cut them to pieces before they could fly back to their ships They also captured 150 persons, who were taken to London roped together

like a team of horses. These were all hanged as a warning to others, some in London and the rest at various places on the sea coast of Kent, Sussex and Norfolk, for sea marks or lighthouses to teach Perkin's people to avoid the coast.

It was an unpromising beginning for an enterprise that had as its goal a splendid crown.

Perkin himself was too cunning to land with the first party, and seeing their defeat he sailed away back to Flanders.

After a time it was felt by Perkin and his followers that something more must be done or the fire they had kindled would flicker out. The young man therefore sailed for Scotland to enlist the help of James the Fourth, who received him at Stirling. Perkin told his tale and James declared that he was convinced that the visitor was really the Duke of York, that he would embrace his cause, and that he should not repent him of putting himself into his hands. As a proof of his goodwill the King gave him for wife the Lady Catharine Gordon, daughter of the Earl of Huntley and near kinswoman of his own, a very beautiful and virtuous lady. Then, raising an army of border folk, James, accompanied by Perkin, made a raid into Northumberland.

A Scottish Joke

When these rough warriors began wasting the country of his supposed subjects Perkin pretended to be very remonstrated with King James, but that monarch only made a half joking reply and the Scotsmen went on wasting and pillaging the countryside.

James after a time came to suspect the self styled Duke of York as a counterfeit, and he asked him to leave Scotland and seek out some fitter place in which to stay. Perkin however could not go back to Flanders, for Maximilian had changed his mind and become friendly with Henry. He therefore sailed with his wife and a number of followers to Ireland.

The Irish had given him very little support and the Earl of Kildare looked upon his cause with very cold eyes.

Exeter Closes its Gates

Three thousand Cornishmen joined him and he now issued a proclamation in which he no longer styled himself Richard Duke of York but Richard the Fourth King of England. His helpers suggested that it was important he should capture some walled city, and so he marched to Exeter and demanded admission.

The citizens however closed their gates and sent off secretly to King Henry for help. Perkin's army had no artillery but they tried to take the city by scaling the walls and by setting the gates on fire. The citizens however repelled the attack and the besiegers were driven from the walls with the loss of 200 men. The King hurried forward an army to the help of his loyal subjects, and Perkin decided that discretion was the better part of valour and marched off to Taunton. Bacon with dry humour tells us that he was beginning already to squint one eye upon the crown and another upon the sanctuary.

Perkin was placed in the stocks at Westminster

The Leader Deserts His Men

His army was now about 7,000 strong, and when he reached Taunton Perkin pretended to be very optimistic and prepared to give the King's forces battle. But he was a man of straw, for about midnight he with sixty horsemen left his followers in the lurch and fled to Beaulieu in the New Forest, where he took sanctuary in the Abbey. It was a poor and mean spirited end to so ambitious an enterprise.

Any leader who leaves his followers in the lurch and seeks safety for himself can no longer count on support for his cause. So it was with Perkin Warbeck. Henry had by this time made a joyful entrance into Exeter and he consulted with his council whether he should not spare Perkin's life if he would come out of sanctuary and voluntarily surrender.

Some members of the council advised the King to take the Pretender by force and put him to death, believing that the Pope would forgive the violation of sanctuary. But others, realising that all danger was now past, urged mercy. The King, never bloodthirsty, took the latter course and sent word to Perkin that if he would surrender his life should be spared.

He, seeing that all hope was gone, accepted the King's merciful offer, and on coming out of sanctuary was made a prisoner and taken to Exeter and then to London. The King however did not have an interview with him, but merely saw him out of curiosity from a window.

A few ringleaders of the rebellion in Cornwall were executed, but the mass of the rebels were again pardoned. Perkin was mocked as he rode on the journey to London, and in the City itself he was conveyed leisurely on horseback through the streets so that the people might see the pretender for themselves.

The people of Cornwall had some time before revolted against Henry on account of the taxes that were wrung from them for his wars. Some of them had marched to London, where they were soon defeated. Their leaders were executed, but the mass of the people were pardoned and allowed to return home. They were however still somewhat discontented and it was suggested to Perkin that Cornwall would be a good place in which to make an invasion of England.

He therefore gathered a small force of about 120 fighting men, embarked them in four small vessels and sailed from Ireland for Bodmin, where he landed.

Perkin in the Stocks

Perkin wrote a full account of his early history and how he had come to impersonate the Duke of York. His confession was very damaging to the Duchess of Burgundy, and after his fiasco there was no likelihood that any further pretender would stand much chance of success.

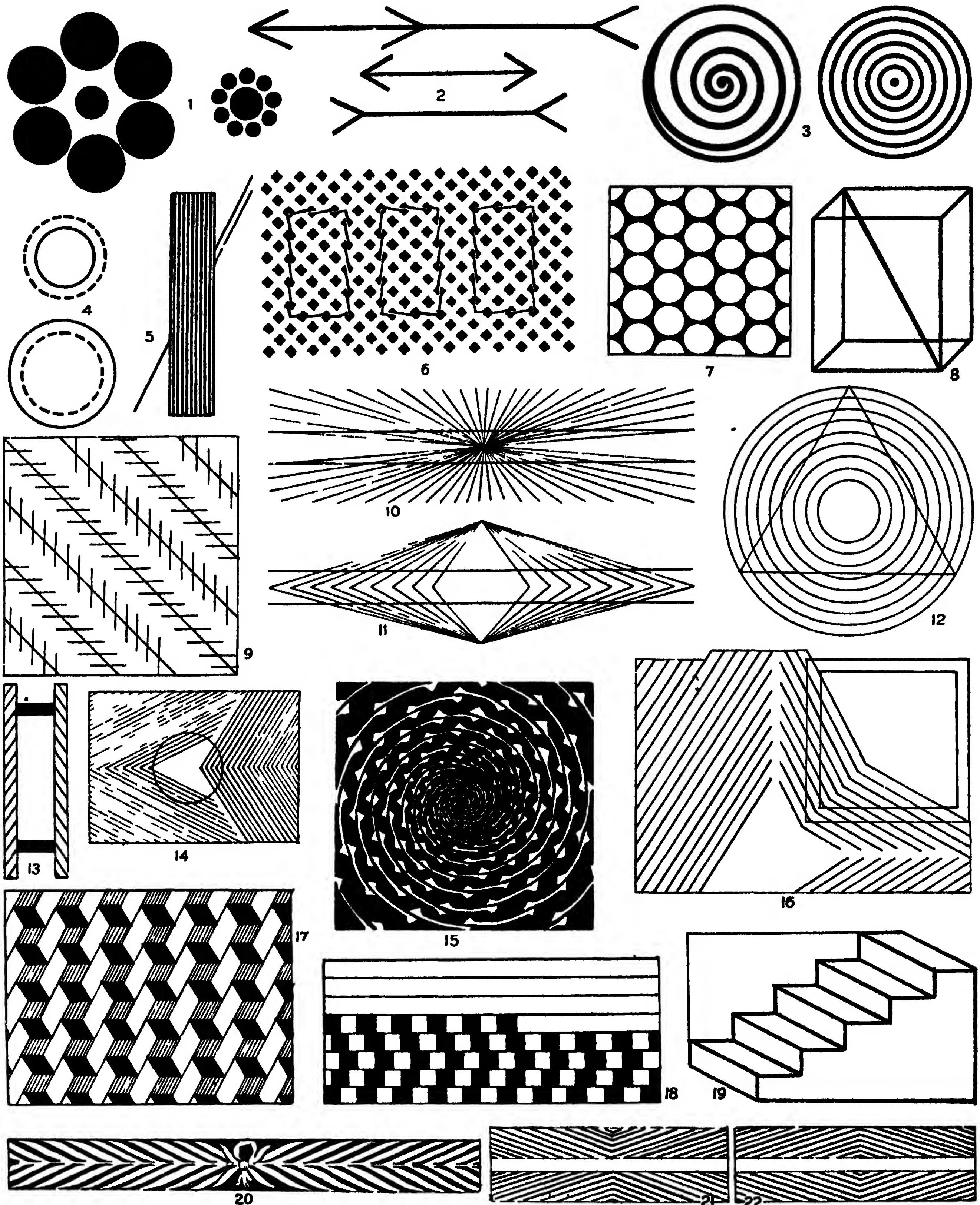
Perkin was kept a prisoner in the Tower of London, but Bacon tells us: "It was not long that Perkin, who was made of quicksilver, which is hard to hold or imprison, began to stir for deceiving his keepers he took him to his heels and made speed to the sea."

Instant pursuit followed and the fugitive was obliged to turn back and once more take sanctuary, this time in the Priory of Shene. The Prior, who was a kind and holy man, went to the King and besought him again to spare Perkin's life. Many of Henry's counsellors urged that the culprit should be hanged, but Henry himself said: "Take him forth and set the knave in the stocks."

Perkin was therefore placed in the stocks, first at Westminster and afterwards at Cheapside, where it is said that he read a confession in public. When a third time he tried to escape the King at last had him hanged at Tyburn.

Henry was very kind to Perkin's wife, the Lady Catharine Gordon, and he should certainly be honoured as the most merciful king that had sat upon the English throne since William the Conqueror.

A WONDERFUL SET OF OPTICAL ILLUSIONS



Here are some remarkable optical illusions In 1 the two black discs in the centre are the same size, although the right-hand one looks larger than the left In 2 all the horizontal lines are the same length In 3 if we rotate this page the spiral and the circle will look as if they were moving round In 4 the dotted circles are the same size, although the bottom one looks larger In 5 we misjudge the continuation of the slanting line In 6 the rectangles are upright but they seem toppling over No 7, looked at from a distance, appears as a series of white hexagons In 8 we seem first to be looking down on the cube, and then up under it In 9, 10, 11, 13, 18, 20, 21 and 22 parallel lines appear curved or slanting In 12, 14 and 16 the triangle, circle and squares appear warped No 15 appears as a series of spirals, but really consists of circles In 17 and 19 we appear to be first looking up and then down upon the blocks and stairs

CAN WE BELIEVE WHAT WE SEE?

Our eyes often deceive us and it is never quite safe to believe a thing merely because we see it It is astonishing what different accounts a number of people will give of some incident or object which they have all seen The eyes have not conveyed the same message to the brain in all cases Here we read many interesting things about our sight and how difficult it is to see things as they really are

How often we hear the expression "Seeing is believing"! There are plenty of sceptical people who seem prepared to believe almost nothing except on the evidence of their own eyes

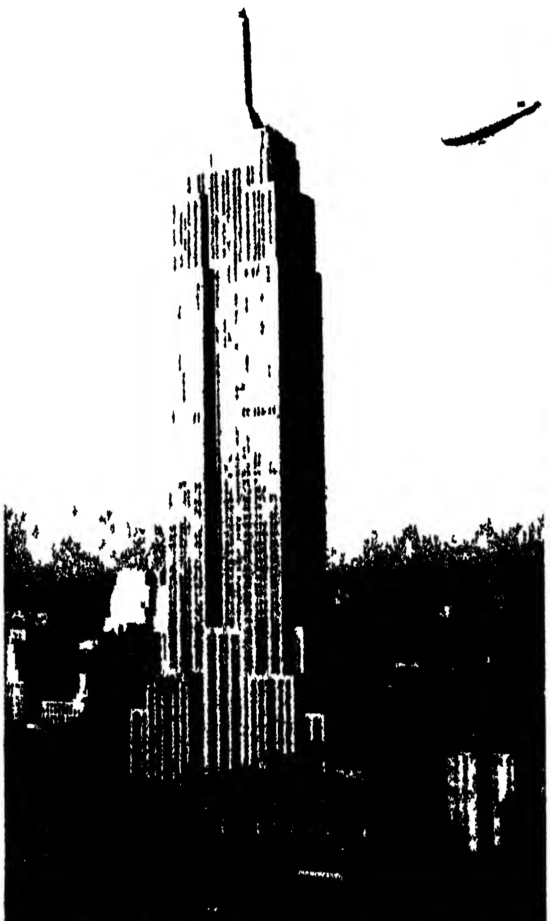
But is it a fact that seeing is believing? Can we trust our eyes and really believe that what we see exists as and where we see it? This is certainly not the case at all Our eyes are deceiving us all the time and many things that we look at are not at all as we see them

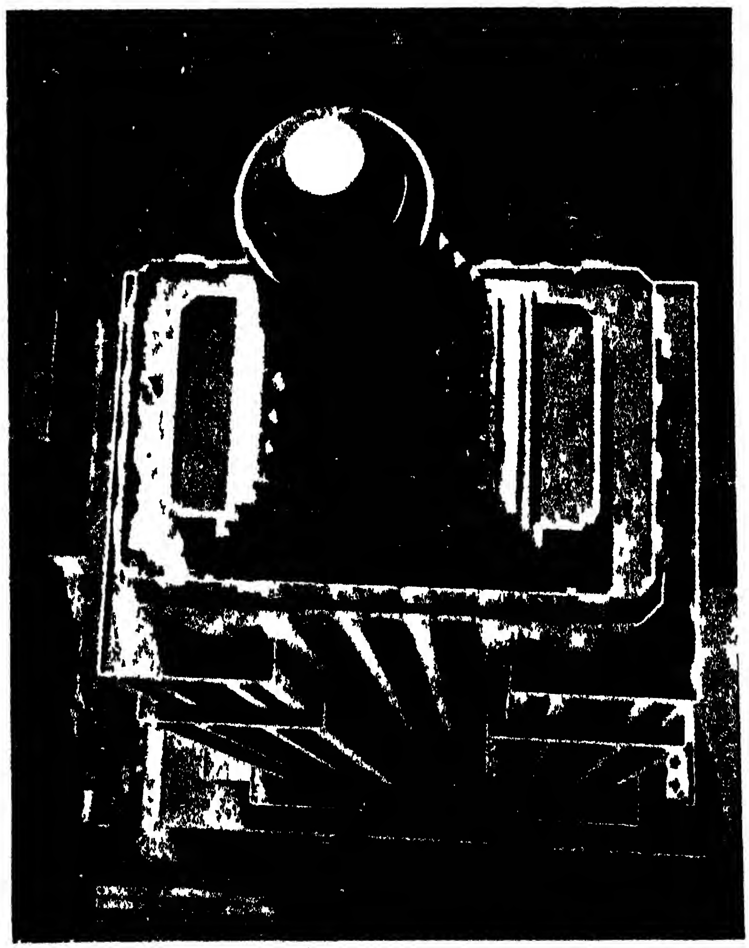
Perhaps the most familiar example is the picture thrown on the screen at the cinema As we look at the screen we appear to see perhaps a street scene Motor cars are running up and down the road people are walking to and fro their mouths move as we hear them speak and so on It all looks very lifelike and what we see certainly appears to be in reality a moving picture in which people behave and act just as they do in real life

As a matter of fact we see nothing of the kind Instead of a continuous scene in which people walk and move their bodies and motor cars run about and trees wave and birds fly what we really see although we do not know it or at any rate do not think about it is a very rapid succession of still life photographs Each one is a little different from the previous one and as these follow one another in rapid succession the images are blended on the retina or screen at the back of our eye so that we get the illusion of one picture with objects moving instead of a succession of many still life pictures

The retina is a very sensitive membrane lining the interior of the eye and it is really an expansion of the optic nerve We look at an object say a tree and the rays of light from it pass through a doubly convex lens known as the crystalline lens in front of the eye and then through a little round hole in a curtain which is called the iris

When we look into a person's eye we see a little black spot in the centre





The left-hand picture shows the Empire State Building in New York from a distance On the right we see it as viewed from above. Of course, the left-hand picture gives the true idea of the building In the right-hand picture, as we look down, the building seems to taper towards the bottom. Since these photographs were taken a large television aerial has been erected on the top of the Empire State Building

which gets smaller when a bright light shines upon the eye and larger when the light is less brilliant. It is not really a dark object at all, but an opening in the iris which has the wonderful power of adapting itself so that just the right amount of light can enter the eye, neither too much nor too little.

Another marvellous power possessed by the eye is that the crystalline lens, through which all the rays pass before they reach the retina, is able to modify its curvature or roundness in such a way as to adapt itself to the distance of the object seen. This is to enable it to throw a distinct and clear image of the object on to the retina. In other words, the lens of the eye is able to focus just as we focus a camera. If the eye did not possess this power most of the things we see would be very indistinct.

A camera lens works on much the same principle as the human eye and can give a completely distorted picture of even such a familiar subject as a man. In the above photograph, the man's feet are out of all proportion to his body because of the angle at which the camera was held

The rays of light from the object as they pass through the lens cross one another, and the image of the object which is thrown upon the retina at the back of the eye is reversed. The picture of the tree, therefore, is upside down, and this is true of everything we look at. Why, then, is it that we do not see things upside down? The answer is that the brain possesses the power of determining the real position of what we see. The eye sees the object upside down, but the brain tells us the correct position in which it is.

It is really very wonderful when we look out of the window, or at the pictures in this book, or at our friend on the other side of the table, to think that the images of all these things on the screen of our eye are upside down.

Quick Movement Deceives the Eye

Now when the retina has been exposed to light or to some bright object and then the object is removed, the retina does not at once stop giving a sensation of light. The time required for the sensation to subside is about one-tenth of a second for a bright light and one-eighth of a second for a moderate light.

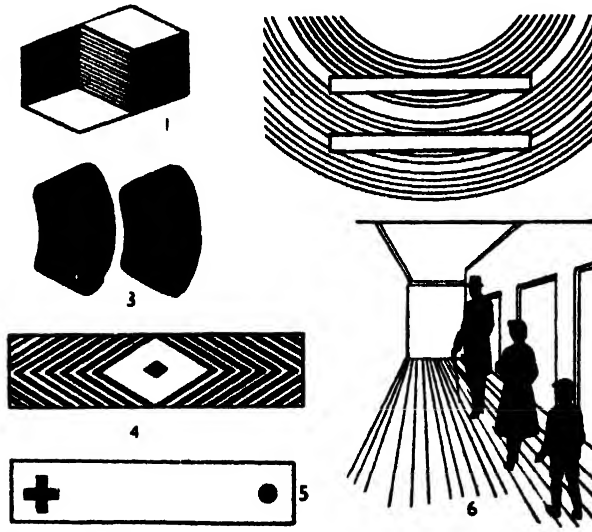
When someone takes a stick from the fire and moves it round and round in a circle we do not see the glowing end of the stick as a point going round and round; what we see is a continuous bright circle. The reason is that when the image of the glowing end had been impressed on our retina at one point it does not immediately disappear when the image appears from another point, and so as the stick is moved round and round rapidly the successive impressions remain long enough for the glowing point to appear as a continuous circle. We think we see a circle of light, but we actually see nothing of the kind.

If we want to realise how thoroughly unreliable our eyes are we should examine some of the optical illusions given on this page and on pages 65 and 462. Look, for instance, at the first illusion picture on page 65. You would never dream that the curved lines are all circles. Yet such is really the case. The plaid background has distorted our sight, and we do not see the lines as they really are. Then again look at No. 15 on page 462. We might be quite sure when we look at this that the lines are spirals all emanating from a centre, but if we follow them round with a blunt point we shall find that each is a definite circle. Even after we have convinced ourselves of this by testing we can scarcely believe as we look at the picture that the lines are not spirals.

Now consider the drawings at the foot of this column. In No. 1 the tops and bottoms become reversed if we look at them for a moment or two. In No. 2 the straight white lines are parallel but seem warped because of the curved lines. In No. 3 the two shapes do not appear to be the same size, although they are. In No. 4 the boundary lines are parallel but do not appear to be because of the herringbone pattern and diamonds. In No. 5 closing the right eye and looking with the left at the dot causes the cross to disappear if the page is brought close to the eye. In No. 6 the three figures are all the same height.

It does not take very much to distract our sight. In No. 16 on page 462 the squares appear very much distorted and are not seen as squares at all. This is because the cross lines deceive us and give a wrong impression. In the same way the circle in No. 14 does not seem to be a circle just because it has been drawn on a pattern of angles.

Perhaps the most striking of these optical illusions are those in which



Here are some more curious optical illusions which make it quite evident that seeing is not always believing. As explained in the text, straight lines can appear curved and figures all the same height seem to be of different sizes

parallel lines are made to appear anything but parallel, by the simple device of crossing them with other lines Many instances will be found on this page The black squares in No 18 also have the effect of distorting the lines just as the black diamonds in No 6 make the rectangles look as if they are leaning to right and left

Our eyes also deceive us very much as to the size of things Examples of this kind of illusion will be found on page 462 in numbers 1 2 and 4 Then look at No 19 a flight of stairs going from the bottom left hand corner up to the top right hand corner As we look however the device seems to change and we appear to be looking at the underside of a staircase just as in No 8 at first the line seems to be going from the bottom right hand corner in front to the top left hand corner at the back and then after a moment or two the whole thing changes and the line seems to go from the top left hand corner in front to the bottom right hand corner at the back In the first case we see the outside right hand face of the cube in perspective and in the second case we see the left hand outside face of the cube in perspective

Evidence of the Eyes

All this should make us very chary about accepting the evidence of our own sight without some other testimony There are cases in which intelligent people in the full possession of their faculties seem to see things which do not exist at all at the place where they see them The late Professor Huxley tells us of a lady who saw her husband standing before her and looking fixedly at her with a serious expression though at the time he was at another place On another occasion she saw a cat in the room lying on the rug and so vivid was the illusion that she had great difficulty in satisfying herself that there was no cat there

Professor Huxley says the lady undoubtedly saw what she said she saw

Here is another interesting example of a perspective view as seen by the eye We are looking down from above on some giant skyscrapers of New York, which appear to be much narrower at the base than at the top This is what we see, but we know that the true shape of the buildings is quite different from their appearance We cannot believe our eye

There can be no doubt that exactly those parts of her retina which would have been affected by the image of the cat and of her husband were thrown into a corresponding state of activity by some internal cause

As a proof of how difficult it really is to know what our eyes have seen, this true incident may be recorded

A distinguished scientist was lecturing to a gathering of scholars and when all was quiet save for the professor's voice and the members of the audience were giving him their close attention a door at the back of the hall suddenly opened and a man in a strange costume rushed up the aisle closely pursued by another man with a knife in his hand The first man when he reached the top of the hall turned round and ran out of a side door the pursuer following him

When Scholars Disagree

The lecturer showed no signs of excitement or disturbance He simply walked across closed the door which had been left open and returned to his place at the desk Then he said

Gentlemen, I must apologise for what has just happened for I had arranged the whole incident I want you to help me carry out an experiment Will you each please write as detailed an account as you can of what you have just seen and let me have your papers as soon as possible

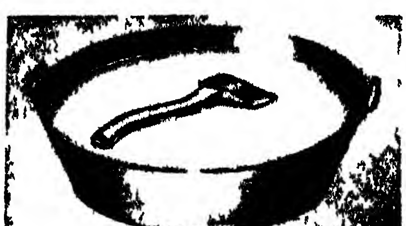
One would have expected that a body of scientists accustomed to paying close attention to what they saw, would have been able to describe this incident accurately But no two of the accounts agreed in all details, only two descriptions of the first man's costume approached accuracy and the whole incident with its sequel should make us very careful about being quite sure of the details of anything we have seen

It is because of this uncertainty that in courts of law witnesses are so carefully and minutely examined about the incidents that they profess to have seen

HOW AN IRON AXE CAN BE MADE TO FLOAT

There is a story in the Book of Kings in the Bible about a man whose axe head flew off the handle While he was felling a tree and sank in the water It was a borrowed axe and he was greatly concerned but the story goes on to tell us that a prophet cut down a stick cast it into the water and the iron did swim " Of course we know that in the ordinary way iron does not float and therefore this story is described as a miracle

But although normally iron will not float on water an iron axe can really be made to float Iron sinks in water because it is heavier than the water being nearly eight times as dense But it will float on mercury or quicksilver because the quicksilver is much denser than the iron being thirteen and a half times as heavy as a similar quantity of water The iron floats on the quicksilver for the same reason that cork and ice float on water They are lighter than the fluid Substances will always float on fluids that are denser than themselves



A wonderful thing an iron axe floating on the surface of a liquid

SUN RAYS THAT WE CANNOT SEE

A SIMPLE EXPLANATION OF THE RADIOMETER

The rays that come to us from the Sun, when passed through a prism, are broken up into the colours violet, indigo, blue, green, yellow, orange and red, and all these we can see with our eyes.

But these are not the only rays that come to us. At both the ends of the spectrum there are other rays quite invisible to our eyes. Beyond the violet are what are known as ultra-violet rays, and at the other end, beyond the red, are what are known as infra-red. The infra-red rays have a much longer wave-length than the rays which are visible to us as light, and some of them are 100 times as long as the longest visible rays.

An English Invention

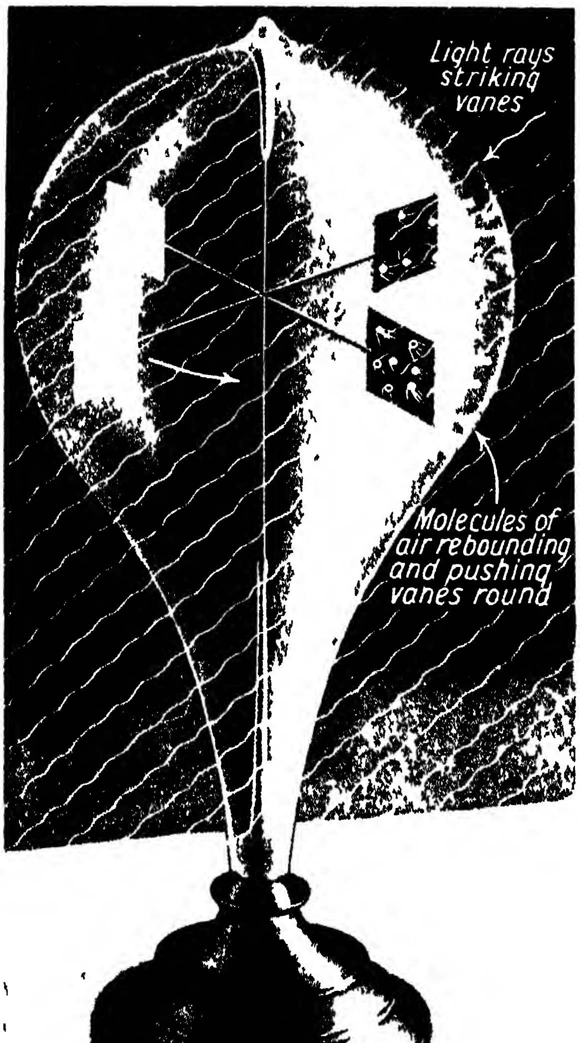
How do we know that these rays are coming from the Sun if we cannot see them and they are not warm enough to feel? Well, they are detected by a very delicate instrument known as a radiometer, which means a ray-measurer, and was invented by the great English scientist Sir William Crookes. Its most usual form is a glass bulb drawn out at one end and resting on a wooden support. Inside the bulb and resting on the most delicate point is a thin rod with four arms, and to each of the arms is fixed a vane of thin aluminium or mica, coated on one side with lampblack. The weight of this tiny windmill is not more than two grains. Almost all the air has been extracted from the bulb.

When this instrument is placed in the sunlight the vanes begin to rotate in such a way that the blackened faces always move away from the rays of light. The explanation given by scientists is as follows: the blackened faces absorb the long heat rays, which are invisible, far better than the polished faces of the vanes, and so become hotter.

When the air was drawn out of the bulb a very minute portion remained behind, for we can never make a perfect vacuum. Of these remaining particles of air those in contact with the blackened surfaces become hotter than those in contact with the polished surfaces and begin to move more quickly. As they strike the dark sides of the vanes they rebound and, as it were, give the vanes a kick, sending them round, and thus the windmill is kept rotating.

Scientists tell us that the glass bulb, because of the pressure of these particles on it as they strike it in their to and fro motion between the vanes and the glass, tends also to rotate in the opposite direction to that of the vanes.

In this sensitive instrument, which we may often see standing in a chemist's or optician's shop window, we can see radiant energy being transformed into mechanical work. The rotation of the little windmill can be brought about not only by the Sun's rays but by those of a candle flame or even the radiations from a human body.



In this picture of a radiometer we see rays of light striking upon the instrument. The darkened sides of the vanes absorb more energy from these than the bright sides, and as a result the molecules of air in contact with the dark sides become hotter, which means they move more rapidly, and in doing so rebound against the vanes and push them round in the direction of the arrows

It is by means of an exceptionally delicate form of radiometer that the amount of heat received from the stars can be measured. At Mount Wilson they have a radiometer so sensitive that it can actually measure the heat from an ordinary lighted candle placed a hundred miles away.

Tests made with this instrument indicate that the bright star Arcturus sends to a square foot of the Earth's surface about as much heat as would come to it from a lighted candle placed at a distance of nearly six miles, that is, supposing none of the candle's heat were to be absorbed as it passed through the air.

The heat from Vega is equal to that received from a lighted candle nearly nine miles away.

How Star Heat is Measured

Sir William Crookes gave the name of radiometer to his little instrument because he thought it could be used to measure the intensity of radiation. The form of instrument used for measuring the radiation from stars is of a far more delicate type than that shown in the picture. The arms on which the vanes are fixed are suspended by an exceedingly fine fibre of quartz, and the whole instrument is much smaller and lighter than that shown here.

When the radiation falls on the darkened sides of the vanes the slightest deflection is detected by watching a spot of light reflected by a small mirror, the movement of the vanes being very greatly magnified.

The radiometers used for these astronomical purposes are so delicate that if the facing sides of two vanes are blackened and the radiation falls upon both, the arms do not move at all, because they are so beautifully balanced and the two sides with their vanes are so exactly of the same weight that the pressures of the molecules of gas rebounding from the two blackened vanes exactly counterbalance one another.

Of course, compared with the wonderful instruments with which astronomers measure the heat of distant stars that are almost countless millions of miles away, the little instrument shown here and often seen in a shop window is little more than a scientific toy. The name that is sometimes popularly given to a radiometer of this form is "light mill," and it is a good name. Even on a dull day the arms can be seen rotating very slowly; on a bright day they rotate rapidly.

DRAWING THE EARTH ON A FLAT SHEET

The round Earth cannot, of course, be accurately represented on a flat surface, but as it is necessary that we should have flat maps, men have devised all sorts of ingenious ways of making fairly accurate representations either of the whole world or of certain parts of its surface. In these pages we read about the most important of these methods or projections, as they are called by geographers.

It is quite impossible to represent accurately on a flat sheet the markings on a round surface. That is why the only really true representation of the continents and oceans and countries and seas of the world is found on a globe. In all our atlases and the flat maps hanging on our walls there is distortion of some kind; either the sizes of the different countries are out of proportion or their relative positions are warped. Why this must be is explained on pages 134 to 137.

Why We Must Have Flat Maps

Of course, while the globe is a very useful and true form of map, it is a very inconvenient one. It takes up a lot of room, and if the individual units are to be of any useful size, so as to show detail, the globe has to be of enormous proportions. Further, it is impossible to carry a globe about with us, and so for convenience we must have flat maps. How are we able to represent the round Earth on a flat sheet?

Men of science have invented different ways of doing it, and the devices they use, which are known as projections, we shall explain briefly. The most familiar map of the world is that drawn on Mercator's Projection. It is a form of what is known as the Cylindrical Projection.

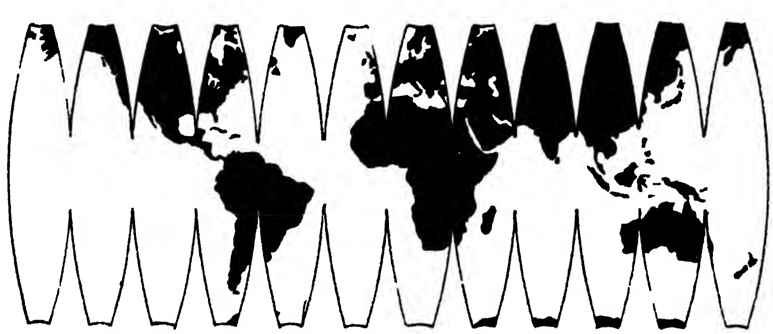
If we take a sheet of paper and roll it up into a cylinder or tube we can place this exactly over the centre of a globe, so that the cylinder touches the globe right round its circumference at the Equator. The map-makers imagine a great sheet of paper placed round the Earth in this way. Then they imagine a number of straight lines passing from the centre of the Earth through the outlines of the continents and countries and seas and islands, and continued till they touch the inside surface of the cylinder of paper. By joining up the various points on the paper by lines they get a representation of the different parts of the world. Then when they unroll the paper they get a map like that shown in Picture 1 on page 469.

Now there is a disadvantage in this Cylindrical Projection. A degree is the 360th part of a circle, and of course a degree of a small circle is smaller than a degree of a large circle.

As we know when we look at a globe, all the parallels of latitude on the Earth's surface are smaller than the Equator. The parallel of 60 degrees, for example, is exactly half the size of the Equator, and so each degree on that line round the Earth is half the size of a degree on the Equator.

At the Equator a portion of the Earth's surface measuring one degree each way, that is, one degree of latitude and one degree of longitude, is a square with each of its sides measuring 69 miles.

But a portion of the Earth measuring one degree each way at latitude 60 degrees, while it is 69 miles long measured from north to south, is only 30 miles when measured from east to west.



The most accurate way of representing the round world on a flat surface is to show it in segments, as indicated here, but such a map is of very little use. These segments, however, would form a covering for a Terrestrial globe.

A map of the world drawn on the Cylindrical Projection does not show this difference in proportion. Mercator, therefore, while he kept to the Cylindrical Projection, modified it. While he kept the degrees of longitude uniform he increased the degrees of latitude in their proportion toward the poles, and so this, while it preserved the shape of the different parts of the world, distorted their size out of proportion.

The Earth Inside a Cone

Mercator's Projection is, however, a very useful form of map for seamen, because routes from one point to another can always be marked by straight lines. The Mercator map is very accurate for those parts of the Earth near the Equator.

Another kind of projection is made by using a cone of paper instead of a cylinder, and this is called the Conical Projection. The cone, of course, cannot touch the globe at the Equator, but according to whether it is a tall or short cone it can be made to touch any particular parallel of latitude. Lines are then imagined to pass from the centre of the Earth through the outlines of the countries to the inside surface of the paper cone, and when these are joined up and the cone unrolled we have a flat representation of the continents, oceans, and so on.

The Projection for our Islands

It is an excellent projection for the band of the Earth's surface near the part of the cone which touches the globe, as in Picture 2, but of course the lower parts of the cone are distorted. The projection is used for small areas, and even for larger areas up to the size of Europe. The maps of the British Isles in our atlases are generally drawn on the Conical Projection. By varying the shape of the cone we can make it touch the globe at any parallel of latitude.

There are various modified forms of the Conical Projection to get certain advantages. One is known as Bonne's Projection, another as the Intersecting Conical Projection. In the latter, when a considerable extent in latitude is to be shown on the map, the cone is supposed to cut into the sphere instead of merely touching it.

Another variation is the Polyconic Projection, in which a number of sections of surfaces of successive cones are assembled together, giving an approximate accuracy for all parts of the globe.

Another device is the Orthographic Projection, orthographic meaning "drawn straight," while the word projection means "thrown in front." In this projection we draw the Earth as we are supposed to see it if we could view it with very sharp sight from a distance in space so great that

instead of the rays of light from our eye to the Earth being slanted as in an ordinary perspective view, they were straight, as shown in Picture 3

In this projection it is clear that while the parts of the Earth immediately opposite our eyes appear reasonably accurate in size and shape those above and below and at the sides are distorted by perspective In Picture 3 we see why this is so The spaces between the lines on the globe are equal but when these are projected on to a flat surface the space nearer the poles appear less than half the distance of the corresponding spaces nearer the Equator The projection therefore is of little use except to give us an idea of what the Earth looks like from space or to map the Polar regions It shows the Earth as a photograph would show it taken from space

Crowded Edges

In order to overcome the difficulty in the Orthographic Projection of having the centre of the map fairly accurate while the edges are too much crowded another device has been invented known as the Stereographic Projection In this we imagine the eye to be placed at the surface of the Earth and looking through the sphere as though it were transparent Lines are then drawn from the eye to each point on the Globe and are supposed to be continued till they meet a sheet of paper placed in front of the Earth and touching it at a tangent The outlines of the land and sea are then drawn on this flat surface The objection is that certain areas become exaggerated in size as can be seen in the map drawn according to this projection in Picture 4

The distortion, however is not very great, nothing like so great for instance as in the Cylindrical Projection and many people regard the Stereographic Projection as being the best for showing the Earth There are variations of this idea in two other methods In the Gnomonic or Central Projection Picture 5, the plan is the same except that the eye, instead of being on the opposite surface of the Earth, is imagined to be at the centre, while in the Equidistant or Globular Projection Picture 6, the eye is imagined at neither of these places but is supposed to be at some distance from the Earth and looking through it In this way the various areas of the globe projected on the flat surface are equal there also

The only true way of representing the Earth is on a globe, as shown in this relief globe by George Philip & Son

There are many other projections The Homolographic Projection Picture 7 is a Globular Projection, but in this case the Equator is doubled in length and the various meridians of longitude drawn accordingly so that the figure of the Earth forms an ellipse By this device the whole Earth and not one hemisphere only is shown on the one map This projection is often called the Mollweide Projection from its inventor

Another projection which enables the whole surface of the Earth to be represented in one map is the Van der Grinten Projection, Picture 8 named after its inventor In this the central meridian and the Equator are straight lines cutting one another at right angles, while the remainder of the parallels of latitude and meridians of longitude are arcs of circles The outer boundaries are meridian circles This device avoids, to a large extent the angular distortion of Mollweide's Projection A modification of Van der Grinten's Projection shows the whole Earth in one circle

Great Difficulties

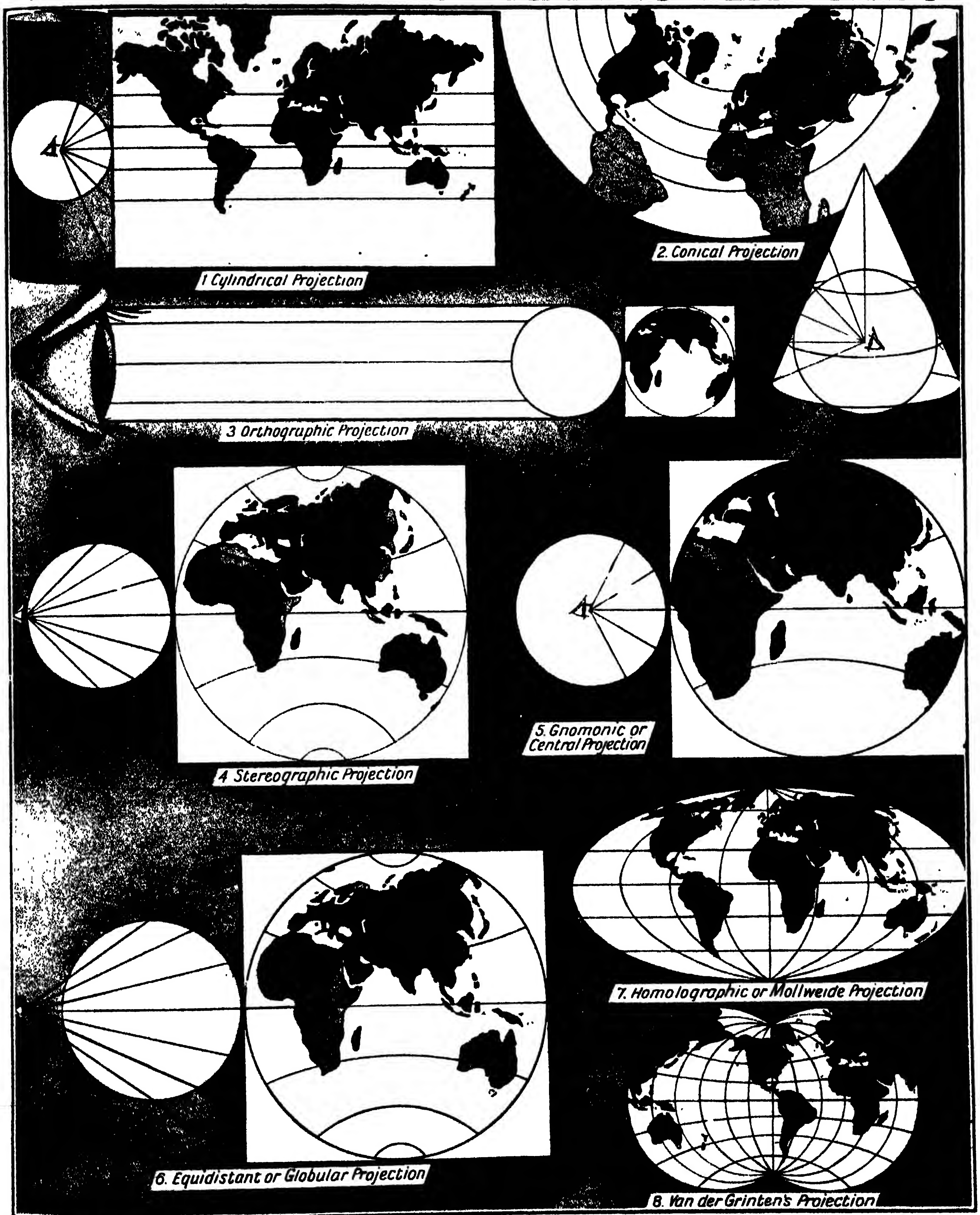
There are various other projections all interesting in their way and each showing some advantage over the others Many of them are merely modifications of those already described here But we have learnt enough to know that it is not easy to map our world or even our country on a flat sheet but that in different ingenious ways men have got over the difficulties

Cartographers nowadays do not fill up the vacant places in their maps with imaginary pictures, as Dean Swift amusingly explains they did in the old days

> Geographers in Afric maps
> With savage pictures fill their gaps,
> And o'er unhabitable downs
> Place elephants for want of towns

It was picturesque but not very accurate, as we may see for ourselves if we can look at the maps in some old atlas of the sixteenth or seventeenth century and compare them with the maps which we find in a good modern atlas It is curious that in recent years there has been a tendency to revive the picturesque practice of putting little pictures on maps as did the old cartographers, while maintaining the accuracy of outline of the moderns.

DIFFERENT WAYS OF MAKING FLAT MAPS



Here are the principal methods of representing the round Earth on a flat surface. In the Cylindrical Projection straight lines are supposed to be drawn from the Earth's centre through the outlines of the land till they touch the inside of a paper cylinder placed over the globe. The cylinder is then unrolled and we have a Mercator map. In the Conical Projection the same method is followed, but with a cone instead of a cylinder. In the Orthographic Projection the Earth is drawn as if viewed from a great distance. In the Stereographic Projection our eye is supposed to be at the surface, looking through the sphere, and lines pass from the eye to each point on the globe, and are continued to a sheet of paper in front of the Earth. In the Gnomonic Projection the plan is the same except that the eye is at the Earth's centre. In the Equidistant or Globular Projection the eye is at some distance from the Earth, looking through it. The Homolographic or Mollweide Projection is a globular projection with the Equator doubled in length. In Van der Grinten's Projection the central meridian and the Equator are straight lines cutting one another at right angles, while the parallels of latitude and meridians of longitude are arcs and circles. Each projection has certain advantages for specific purposes

CALMS, BREEZES, GALES AND STORMS

WHETHER there is a gale, storm or hurricane blowing depends upon the speed with which the wind is travelling. The speed of wind can always be known by means of an instrument called the anemometer, of which there are various forms.

The direction of the wind, of course, is indicated by a vane or weathercock, such as we frequently see on top of a church or other building. To measure the velocity or speed of the wind, however, a different instrument is needed, and we call it an anemometer because that name means "wind measurer." The first one was made in 1667.

The simplest form is called a Deflection Anemometer, which has a square board or sheet of metal hinged at the upper edge. This is kept always

to the amount of pressure so the speed of the wind can be determined.

But the most common form of wind gauge is known as the Cup Anemometer. In this four cups are attached to the end of a light metal cross, and this rotates under the force of the wind. As it does so the rate of revolution is registered on a dial, and the figures on the dial are made to correspond with the speed of the wind.

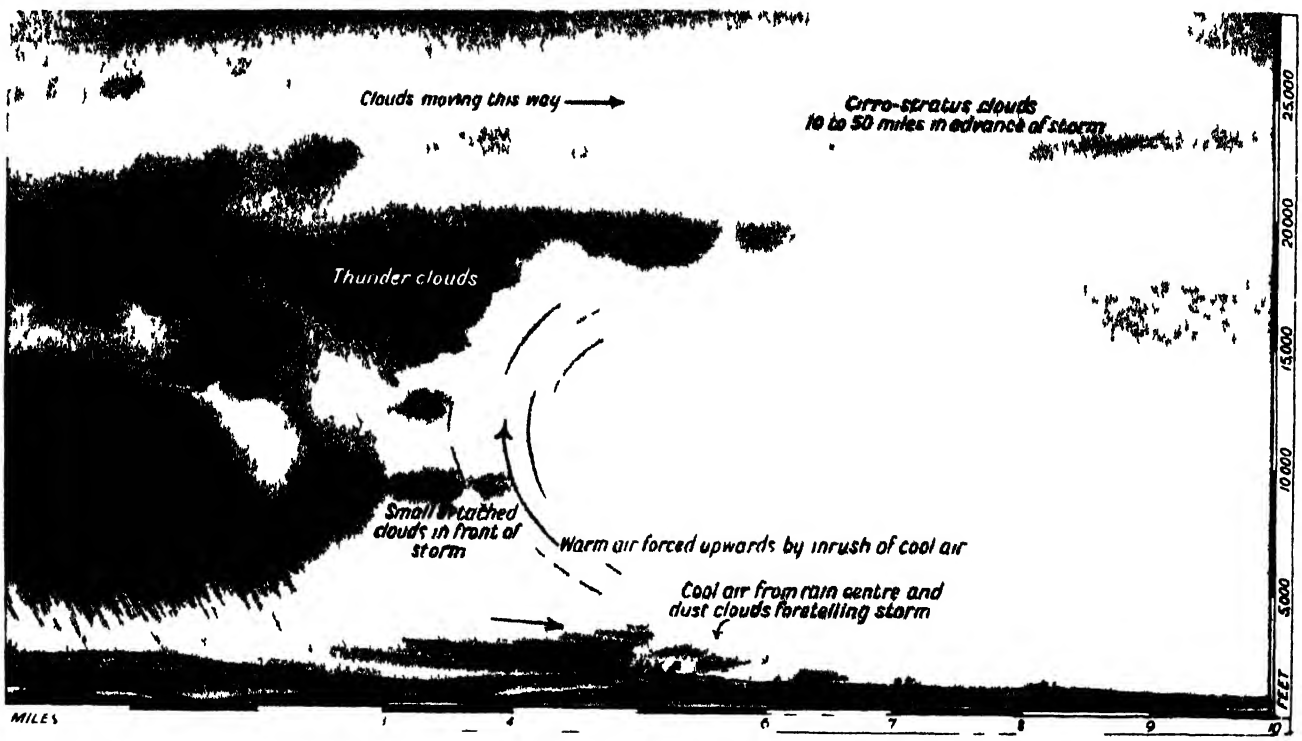
To describe the wind at any time there is a recognised scale based on its speed, and this is known as the Beaufort Scale, after Admiral Beaufort of the English Navy, who devised it in 1806. This scale is still used, although it has been modified somewhat from its original form.

According to the scale now used, when there is practically no wind that

gale, from 56 to 63 miles a storm, and when the wind is travelling at 64 to 71 miles an hour it is called a hurricane.

These various classes of wind are numbered by meteorologists from 1 to 12, the light air being called 1 and the hurricane 12. A calm in the scale is called 0.

The gentle breeze sets leaves and small twigs in motion. The moderate breeze raises dust and loose paper and moves the smaller branches of trees. The fresh breeze sways the smaller trees when they are in leaf. The strong breeze sets the large branches of trees in motion and we hear whistling in the telegraph wires. When there is a moderate gale whole trees are set in motion, and a fresh gale breaks off twigs.



In this picture we see a thunderstorm moving towards the right. From ten to fifty miles in advance of the storm, cirro-stratus clouds are seen travelling some 20 000 to 25 000 feet above the ground. Soon a cool wind blowing at a low level stirs up clouds of dust from the ground and drives up the warm air which it meets. Before long small detached clouds cover the sky and immediately behind follow the dark thunder clouds and the rain with a heavy fall of large drops. After the thunderstorm has passed the air is generally cooler. The vertical and horizontal scales in this drawing are not the same. A thunderstorm has an average height of about four miles and a length of about 70 miles.

from the wind by means of a vane which turns the apparatus. When the wind blows on the board it deflects it from its vertical position, and of course the stronger the wind the more the board is deflected. A device is added which shows the amount of deflection and records the speed of the wind at the time.

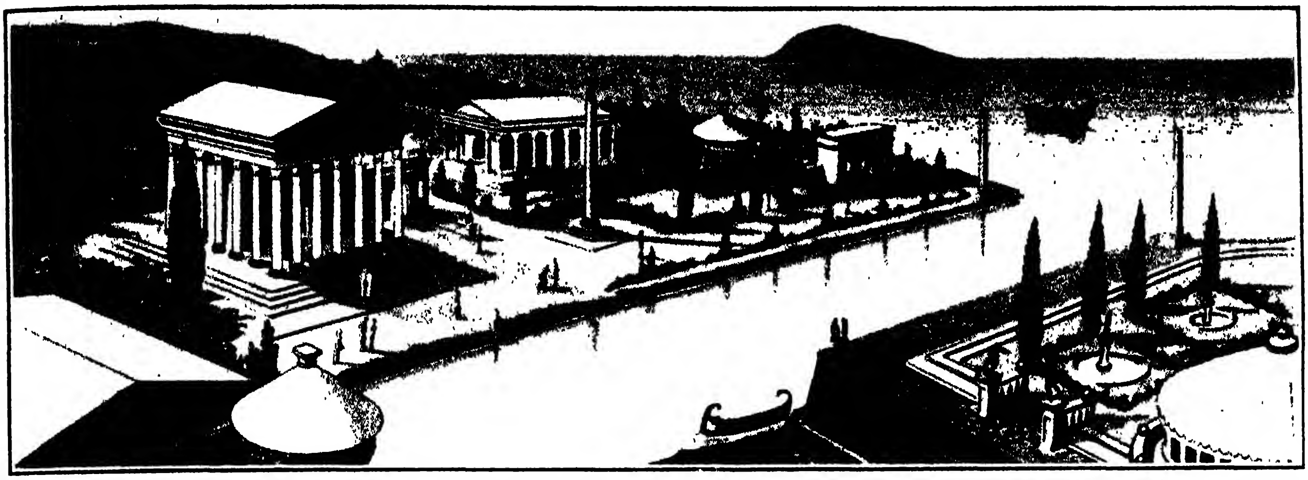
Another form of the instrument is called a Pressure Anemometer. In this a board kept facing the wind by means of a vane is held in position by a spring. As the wind increases in speed the board is pressed more and more against the spring, and according

is when the air is moving at a rate of less than 1 mile per hour, so that smoke rises vertically from chimneys, we say there is a calm.

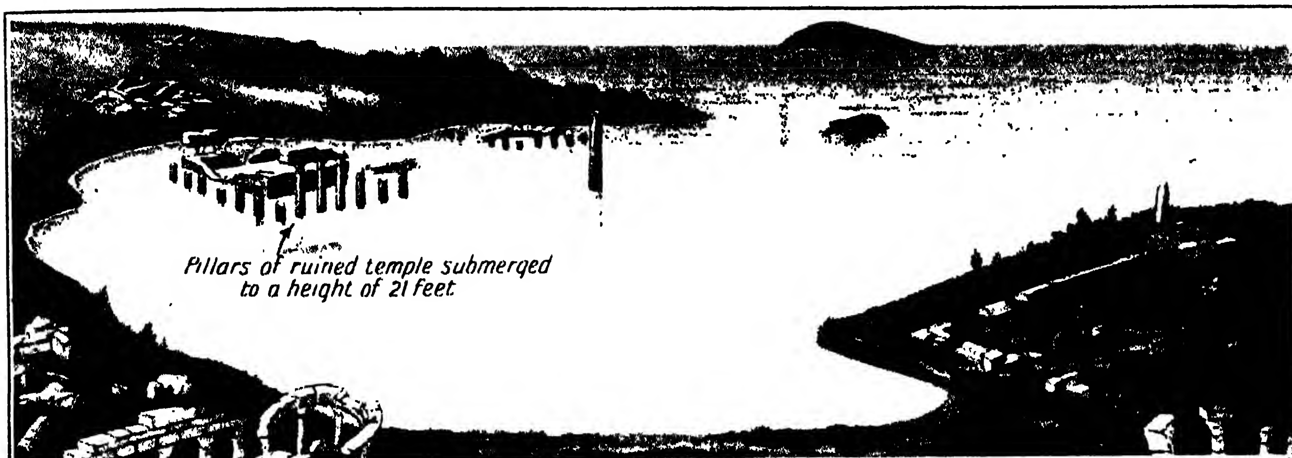
When the wind blows at a speed of from 1 to 3 miles an hour it is called by the Beaufort Scale a light air; from 4 to 6 miles an hour it is a light breeze; from 7 to 10 miles a gentle breeze; from 11 to 16 miles a moderate breeze; from 17 to 21 miles a fresh breeze; from 22 to 27 miles a strong breeze; from 28 to 33 miles a moderate gale; from 34 to 40 miles a fresh gale; from 41 to 47 miles a strong gale; from 48 to 55 miles a whole

A strong gale blows chimney pots from roofs, and a whole gale uproots trees besides doing other damage. A storm, which is rarely experienced in Great Britain, does widespread damage and often blows down many telegraph and telephone poles. A hurricane will throw over a motor car, and when it is a bad one will sometimes derail trains. A wind is always named from the direction from which it comes, and that direction is called "windward." The direction towards which it goes is called "leeward." Thus if the wind is blowing from the north it is called a "north wind."

HOW WE KNOW THAT THE GROUND SINKS AND RISES



Much of the ground on which we walk was once under the sea. This is true of most of England. As we walk over the chalk downs we are walking over myriads of tiny shells of sea creatures which, when they died, fell to the bottom of the sea, and were gradually compressed into solid chalk rock. Then later the sea-bed was upheaved. But in some places the dry land has been under the sea more than once. This is the case with some parts of Italy, and a wonderful proof of this fact is to be found in the ruins of the ancient temple of Jupiter Serapis at the little town of Pozzuoli, near Naples, shown here as it appeared in the third century



Gradually the land on which the temple stood sank, till the waters of the sea encroached and submerged the temple, as shown in this picture. This was in the ninth century, and we know that the water rose till the pillars of the temple were 21 feet under water. The lower part of each column was at that time buried in the sand. How we know this is explained below

Here we see what the temple of Jupiter Serapis looks like at the present day, and the picture explains how it is we know that the ruins have been under the sea, and how far they were submerged. On each of the standing columns at a height ranging between 12 and 21 feet there is a band showing a roughened surface. An examination of this roughened surface shows that it has been produced by the borings of a small marine mollusc called lithodomus which lives in the waters of the Bay of Naples, and some of its shells are still to be seen in the cavities on the temple columns. It is clear that what happened is that the whole of the ground was submerged to a depth at which the lithodomus could bore into the pillars, and that below the bands the pillars were buried in sand, which prevented the mollusc from working on the lower parts of the columns. Later the whole was raised out of the water again

MAMMOTH HOT SPRINGS AND THEIR WORK

In addition to the geysers which shoot up columns of hot water and steam there are many large hot springs to be found in different parts of the world Here we see a wonderful hot spring in the Yellowstone National Park, with the steaming water flowing over a picturesque rocky formation known as Jupiter Terrace The mineral deposited by hot springs consists mostly of silica

This picture shows the mammoth hot springs at Wyoming, U S A, with the strange form that the deposited mineral matter has given to the rocks The water of hot springs contains much mineral matter, and as the water evaporates it is deposited in grotesque forms Though hot springs are widely distributed, geysers are confined almost entirely to the Yellowstone Park, Iceland and New Zealand

HOW MEN WORK IN THE DEPTHS OF THE SEA

Deep-sea diving is a great science which requires complicated machinery in the form of a diving dress, air pumps, and various other devices. In recent years diving apparatus has been brought to such perfection that men can now work at a depth of 400 feet below the surface of the sea, where a diver is subjected to a total pressure of 150 tons or more. Here we read many interesting facts about diving and the diver's outfit

The pearl divers of Ceylon and the Persian Gulf, where thousands of persons depend upon this industry for their living, use no apparatus. They dive without even clothes, and frequently remain below the surface of the water for two minutes at a stretch. The modern diver of civilised countries, however, needs what it is no exaggeration to call complicated machinery in order to carry out his work.

Some of the feats of diving which have been performed in recent years are absolute triumphs not only of endurance but of mechanical and scientific perfection. The most notable case, of course, is that of the treasure lost in the P & O liner Egypt in the Bay of Biscay The vessel lay 400 feet deep, and a quarter of a century ago to think of working at such a depth would have seemed absolutely impossible. But this triumph has been achieved, and a considerable amount of the million pound treasure which lies in the wreck has already been recovered.

Gold from the Deep

Another remarkable triumph of diving was the recovery of nearly five million pounds' worth of gold bars from the White Star liner Laurentic, which was mined or torpedoed in Lough Swilly, in 1917. Here the divers worked at a depth of 120 to 130 feet, and with an expenditure of only £138,000 recovered from the wreck £4,958,000.

Of course, diving is not at all a modern practice, although the present type of diving dress is only about a hundred years old. There were divers in ancient times, for Homer refers to them in his Iliad, and Alexander the Great not only used divers at the Siege of Tyre, but is said himself to have made a descent into the sea in a machine called a colympha, which was able to keep a man dry under water

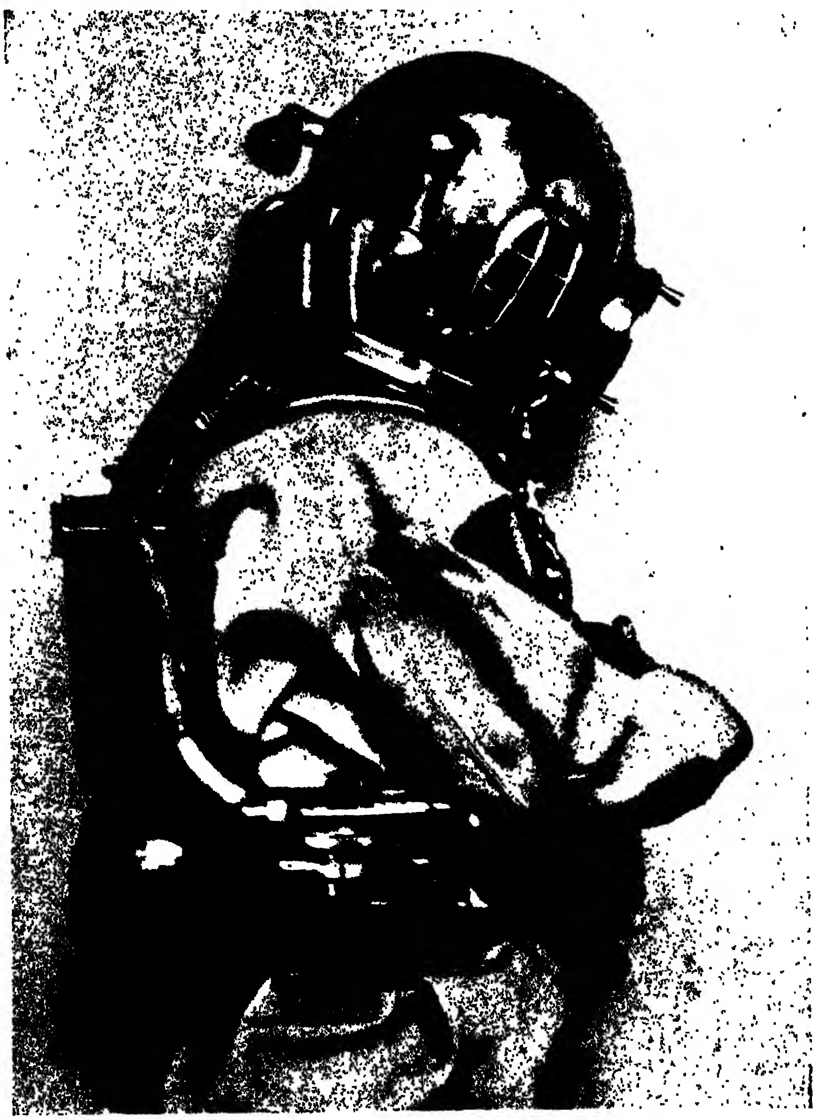
These old divers, while below the surface, had some kind of apparatus enabling them to breathe, and we are told they drew in air through a tube, one end of which they carried in their mouths, while the other end floated on the surface of the water. Perhaps they got the idea from the elephant, who when in deep water keeps his trunk above the surface so as to breathe in fresh air Aristotle tells us of divers who breathed by means of a vessel made of metal let down into the sea, which did not get filled with water, but retained the air.

It would be tedious to describe the evolution of the diving costume of to-day, but it should be mentioned that it is to Augustus Siebe that we owe the diving dress which in various forms has proved so efficient

Constant Fresh Air

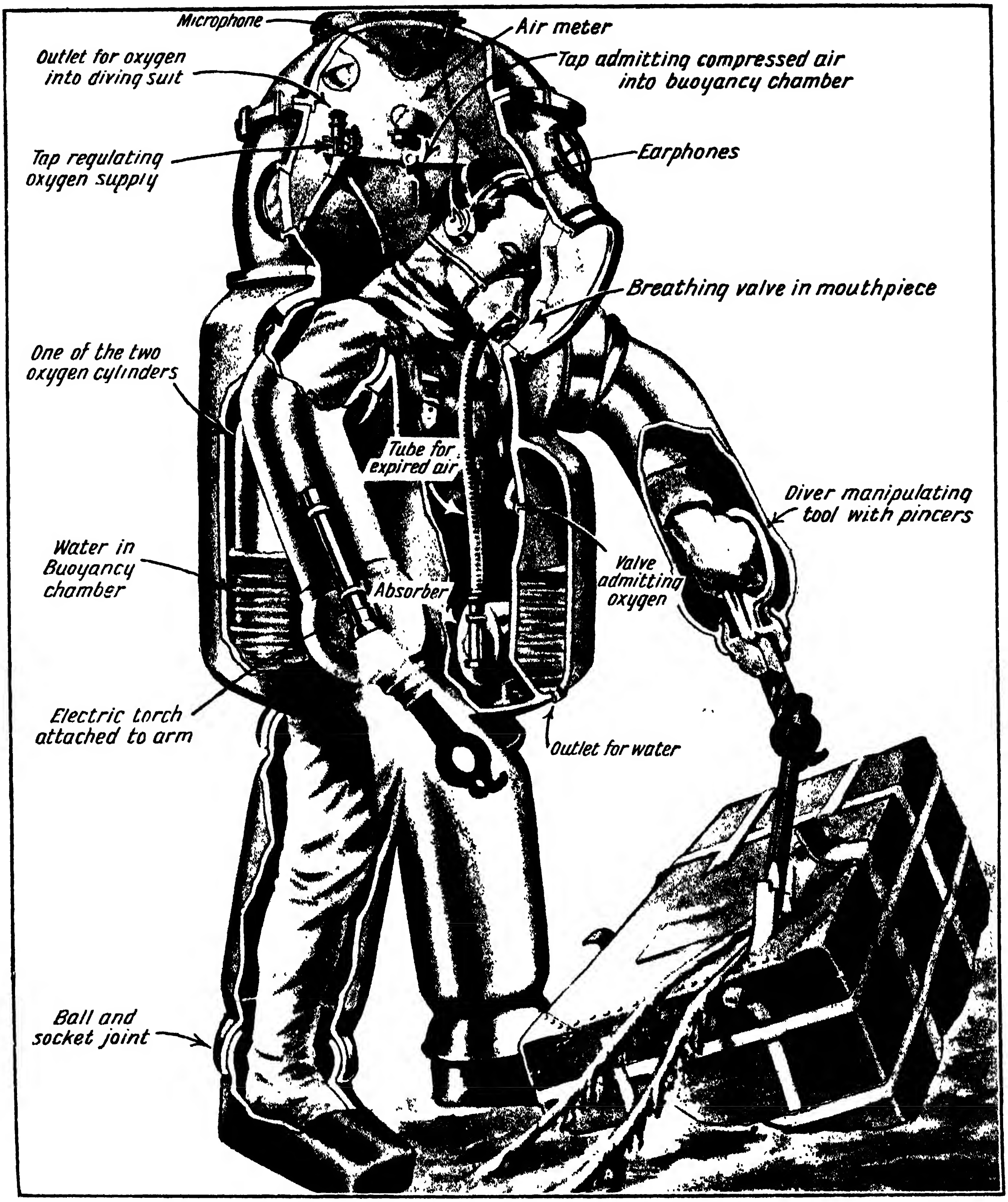
In 1819 he made a metal helmet and shoulder plate attached to a water tight jacket fitting closely to the body, and this was worn with a combination trouser suit reaching to the arm-pits. The helmet had an inlet valve and air was pumped into the helmet through a flexible tube attached to an air-pump at the surface of the water.

In this way the diver was supplied with a constant stream of fresh air, and at the same time the air kept the water from rising far up in the suit. After use it escaped by forcing its way between the jacket and the under-garment, rising through the water as bubbles. Because of



A self-contained diving suit made by Messrs. Siebe, Gorman & Company, the firm founded by Augustus Siebe, the inventor of the modern diving dress. Here the diver carries his own air supply. In front he has metal cylinders of compressed air and oxygen, and at the back a chamber containing chemicals where the carbon-dioxide breathed out is absorbed and the air made pure for re-breathing

HOW A MAN CAN WORK DEEP DOWN IN



Divers can now work at a depth of 400 feet, and remain below for several hours, by using the special deep sea apparatus shown here. At 400 feet the pressure on a diver's body is over 150 tons An ordinary diving dress is therefore useless. Instead, this steel case is used. The outside is cut away to show us what is going on inside. The deep sea diver carries his own supply of oxygen compressed in two cylinders behind him. He regulates his supply by turning on a tap. When he breathes in, air comes through a little non-return valve in front of the mouthpiece. The air which he breathes out goes into a tube and passes through an absorber containing caustic soda, which extracts the carbon-dioxide. The air then passes out into the interior of the diving case, where it mixes with oxygen from the cylinders. The diver is surrounded by a buoyancy chamber filled with water, to make the apparatus heavier, so that he may sink. If he wishes to make himself lighter for moving about, he turns on a tap which admits compressed oxygen from the cylinders, and this

THE SEA WITH 150 TONS PRESSING ON HIM

forces out water through an outlet at the bottom. A meter shows him how much air is in the chamber. He is in communication by telephone with those above, and their voices reach him through earphones, while when he speaks, his words are carried through a microphone. The diver is raised and lowered by a crane, and those above let down a lamp to assist him. He also carries an electric torch fixed to one arm. Various pincers are also fixed on the arms before he descends. The picture on the right shows the diver using an oxy-acetylene torch to cut through the iron plates of a wreck. Ball and socket arrangements in most of the joints of the steel case allow of slight movement, but, of course, the man cannot move his arms and legs like an ordinary shallow-water diver ; he can on'y move his arms inside the diving case. The diver when at work wears a suit of thick woolen material to keep him warm. This apparatus is made by Siebe, Gorman & Co., the submarine engineers of Westminster, who make the finest diving apparatus in the world

this the diving suit was spoken of as an "open" dress. It was the first real big step forward in the production of an efficient diving dress.

But there was one great disadvantage with this early invention. If the diver stumbled and fell the water filled his dress and unless he could be brought to the surface quickly he was liable to be drowned.

To overcome this defect Siebe carried out a great number of experiments extending over several years, and at last in 1837 he produced his "close" dress used in combination with a helmet fitted with inlet and outlet valves for the air. This type of dress, which is still used, was worn by divers in the later stages of recovering the guns and other things from the Royal George which sank at Spithead in 1782.

Of course great improvements have been made in the Siebe costume, but its principle is still in general use.

Deep Sea Dresses

In some of the modern diving dresses the diver, instead of depending upon air being pumped through a tube from above, carries his own air supply with him. In a metal chamber at his back are chemicals which absorb the carbon dioxide as he breathes it out so that he can use the air again, and in front he has cylinders containing a reserve supply of air and oxygen. If necessary he can add more oxygen to the air which he is breathing.

Then, for very deep diving there are all-metal dresses with flexible joints, the diver looking very much like one of the old knights in armour. For still deeper diving the "dress" really consists of a large metal chamber shaped more or less like a man, and we can see devices of this type on pages 474 and 475.

The ordinary diving costume consists of a combination suit made of two layers of tanned twill with india-rubber between. It covers the whole man from his feet to his neck, and the wristbands are made quite water-tight. The helmet, which is of the greatest importance, is very strongly made of copper, with valves and other parts of gun-metal.

There is an inlet valve through which an air supply can enter, and an outlet valve which is regulated by the diver so as to control the amount of air in his dress. In this way he is able to increase or decrease his buoyancy.

The helmet is fastened to a breast-plate and corselet, and to this the rubber and twill suit is fastened in such a way that the whole costume is watertight.

Unless a man carries his own air supply an air pipe connects his helmet with a pump at the surface, and there is a life line for hauling the diver quickly to the surface in case of need. In the old days this was also used for making signals according to a code, but nowadays most divers are provided with a telephone, so that while under water they can be in regular communication with the boat above.

They wear heavily weighted boots of stout leather with wooden soles, each being about eighteen pounds, and they have metal toe-caps. Brass boots, with renewable leather uppers, are sometimes used.

Two leaden weights, each of about forty pounds, are worn as well, one on the back and the other on the chest, so that the diver can preserve his equilibrium under water. Sometimes instead of these weights, a belt loaded with slabs of lead is worn round the waist, or, in strong tideways, it may be worn in addition to the front and back weights.

When rough work is to be done canvas overalls are often worn outside the diving dress to protect it. A helmet cushion and shoulder pads are worn inside the dress to protect the body from the weight of helmet and corselet. Electric lamps are used, the lamps being lowered under water before the current is switched on, so that the glass may not crack through being already warm when it touches the cold water.

The strain on the body and heart of the diver is very great, owing to the enormous pressure under which he works, and a diver must be not only absolutely strong and sound, but trained like an athlete and skilled in the technical details of his job. He breathes compressed air all the time because the air inside the diving suit must be under pressure in order to counterbalance the pressure of the water outside.

By breathing compressed air not only is a great strain put upon the lungs, but there is a tendency for an excess of nitrogen gas from the air to pass into the blood, and this causes a great danger.

Recruits at the Royal Navy's Diving School at Whale Island, Portsmouth, floating in their air-filled suits. It is usually by filling his suit with air to make himself more buoyant that a diver comes to the surface

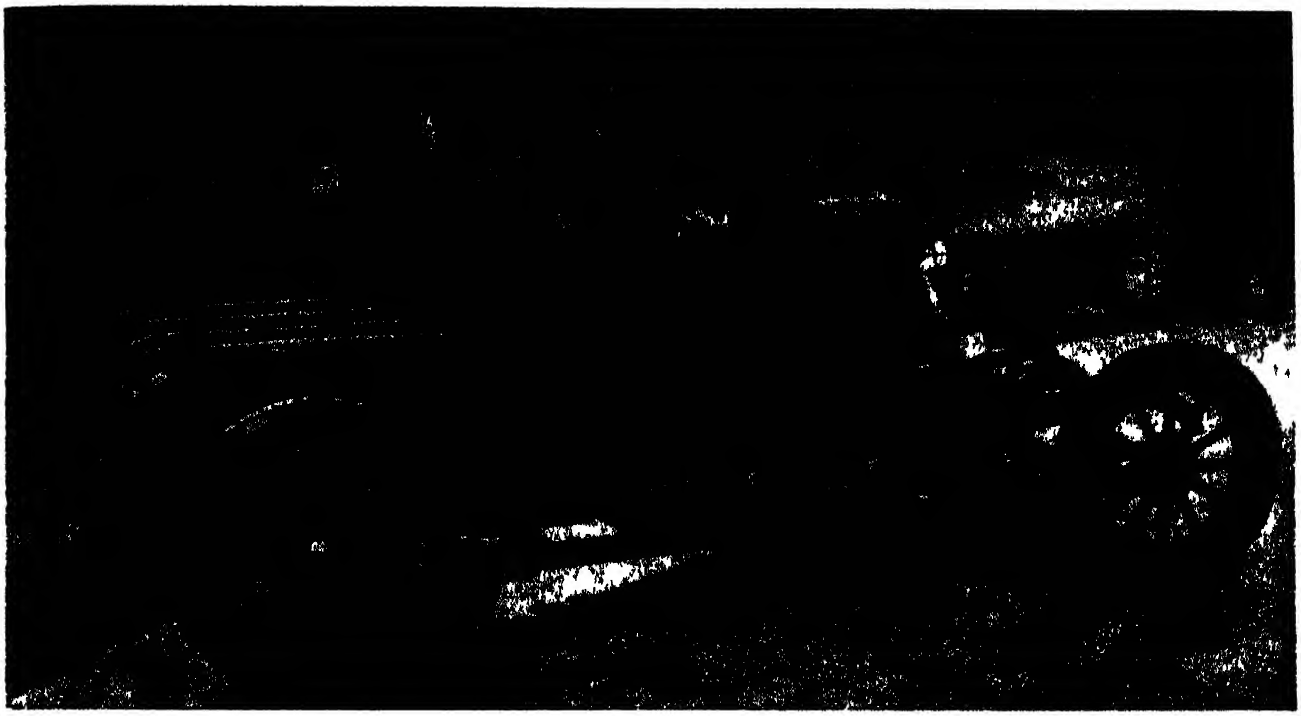
Perilous Bubbles

There is little peril in going down under water; it is in coming up that the risk is incurred. In fact, a diver must travel up very slowly indeed, otherwise the nitrogen in his blood would form little bubbles, and if these bubbles reached his heart he might die or become paralysed.

We know how, when we remove the pressure from a bottle of lemonade or soda-water by taking out the stopper or pressing the tap of the siphon, bubbles of carbon-dioxide gas at once form and rise. It is the same in the blood when the pressure is removed suddenly. The diver is the soda-water bottle, and the blood is the fluid in the bottle.

For this reason the diver who goes down, perhaps, 130 feet in a few seconds takes about an hour to come up. He comes up a few feet at a time, and then rests before ascending a few more feet. By doing this the excess of nitrogen in the blood passes off without forming bubbles, and without danger. To come up 200 feet would take about four hours. It is cold working under water, and so a diver has to be protected with very warm clothing.

A MOTOR-CAR DRIVEN BY COMPRESSED AIR



Various attempts have been made to run motor-cars on fuels other than petrol or heavy oil. Here is a car in which an ordinary internal-combustion engine is driven by compressed air which is stored in the cylinders at the rear. The air goes through the motor forcing the pistons up and down as in a petrol engine. A proportion of the air is recaptured and compressed for use again.

THE DIFFERENT KINDS OF WATER-WHEELS

When water power is to be utilised nowadays the kind of water-wheel that is generally brought into service is the horizontal type known as a turbine, such as is used at Niagara Falls.

There are still, however, in England and elsewhere, many of the old types of water-wheels at work, and the different kinds are shown in the pictures below.

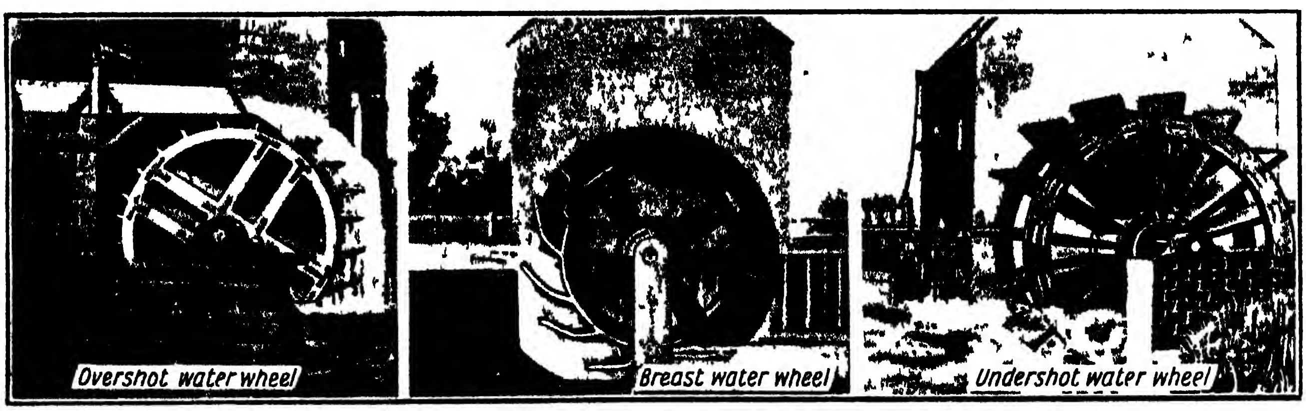
In the overshot wheel the water flows on or near the top of the wheel. It acts chiefly by gravity, that is, the fall of water downwards towards the earth turns the wheel, but some effect is also due to the speed with which the water strikes the wheel.

Overshot wheels are generally used where there is a small quantity of water with a high fall, as in the case of mountain streams. On the circumference of the wheel are arranged buckets into which the water falls on the upper part of the wheel, and then as each bucket reaches the lowest point of revolution it discharges its water and ascends empty.

In an undershot wheel float-boards are arranged radially, and the lowest float-boards are immersed in water which flows with a speed depending on the fall. Undershot wheels are used where there is a large quantity of water but a very slight fall.

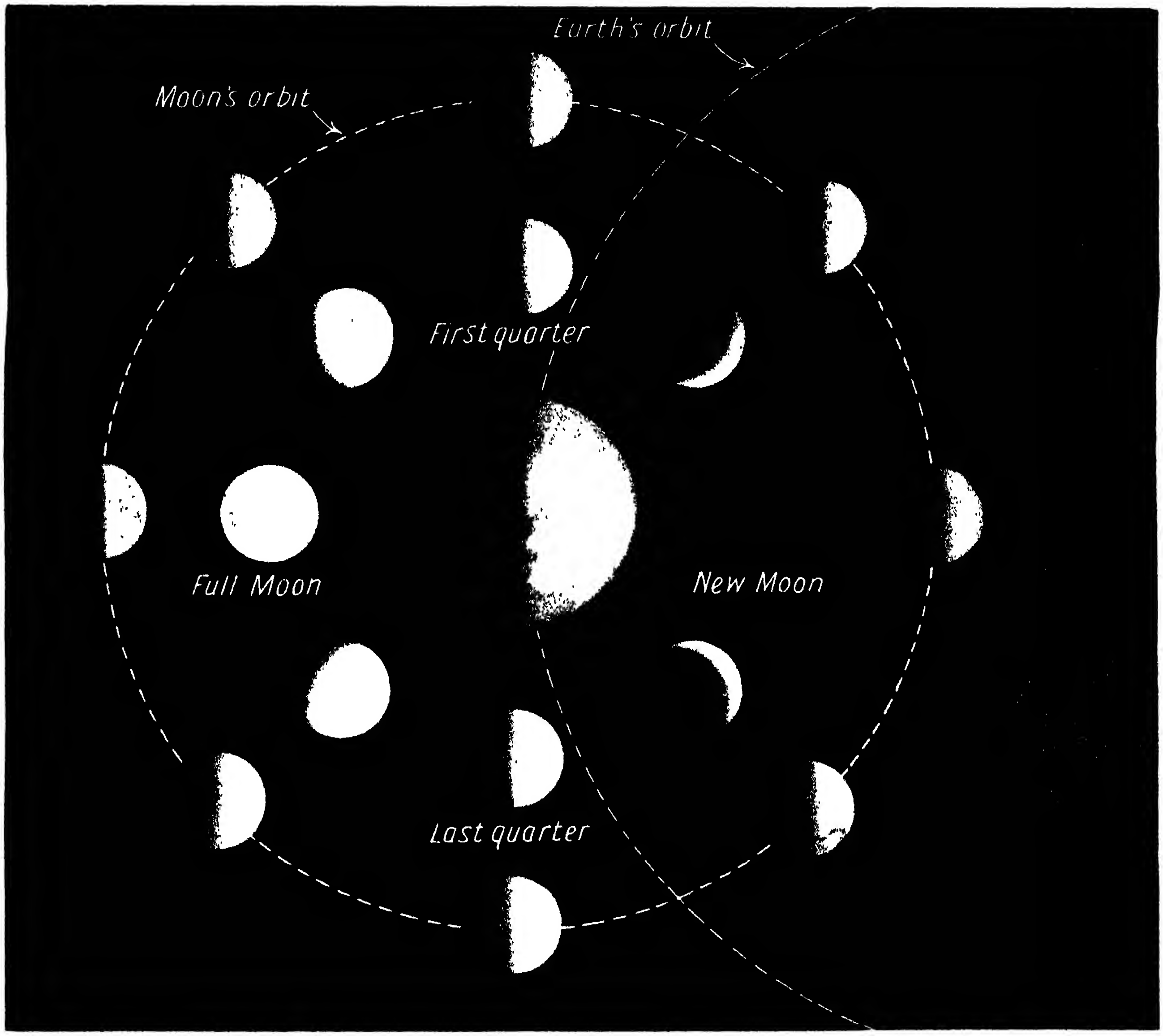
A third kind of water-wheel is known as the breast wheel, and in this the water strikes the wheel at about the level of the axle. It falls upon buckets similar in form to those of an overshot wheel, and where the fall of water does not exceed eighteen or twenty feet it has advantages over both the overshot and undershot types of wheel.

It must be remembered that the full force of the falling water is not utilised by a water-wheel, as the water, after acting on the wheel, still retains some of its velocity and so does not impart the whole of its energy to the wheel, and some of the water flows past without being used at all. Some water-wheels utilise only fifty per cent of the energy of the flowing water, but modern types of turbine are able to yield over eighty per cent of the water's energy.

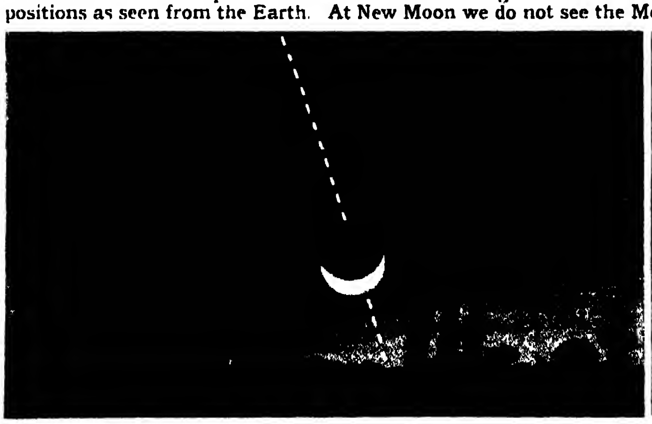


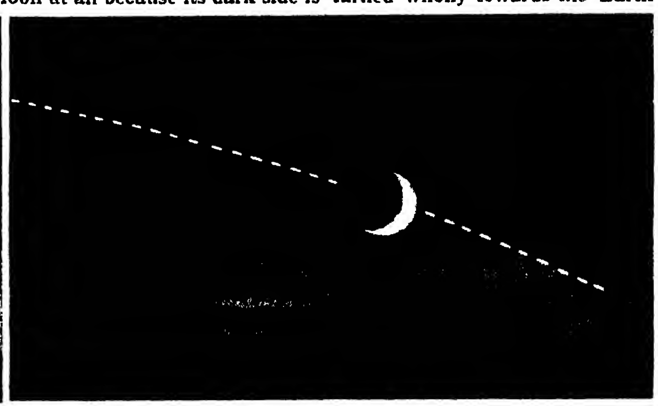
Different ways in which running or falling water is used to turn a wheel and provide power for a mill or other machinery. The form of wheel is determined by the volume of the stream and the swiftness of the current.

WHY THE MOON DOES NOT ALWAYS APPEAR ROUND



We all know that the Moon, as it is seen in the sky at different periods of the month, varies in its apparent shape. This is because it shines only by the reflected light of the Sun and so its phases, as they are called, depend upon its position relative to the Sun. This picture-diagram explains the matter. The Sun is shining from the right and we see the Earth in the centre and the Moon at different positions as it travels round the Earth. The outer circle of Moons given here shows how the Moon would appear at various points in its orbit viewed from distant Space with the Sun illuminating half its surface. The inner circle shows how the Moon appears in these various positions as seen from the Earth. At New Moon we do not see the Moon at all because its dark side is turned wholly towards the Earth





In these pictures, drawn by Mr. George F. Morrell, F.R.A.S., we see the Moon as it appears at different seasons of the year. On the left the Crescent Moon is seen on its back in Spring and Autumn because then the Sun sets at a steeper angle and nearer to perpendicular than it does in Summer and Winter, when the Crescent Moon appears as on the right

WHY THE MOON CHANGES ITS FACE

The moon appears very different to us at different times in the month. Sometimes it is a crescent, sometimes it is a full round disc of light. This puzzled some of the Ancients, who thought it must be a globe half alight and half dark, which turned on its axis, showing us the illuminated and unilluminated regions in succession. But the Greeks found out the true explanation hundreds of years Before Christ. In these pages the phases of the Moon, as they are called, are explained by word and picture.

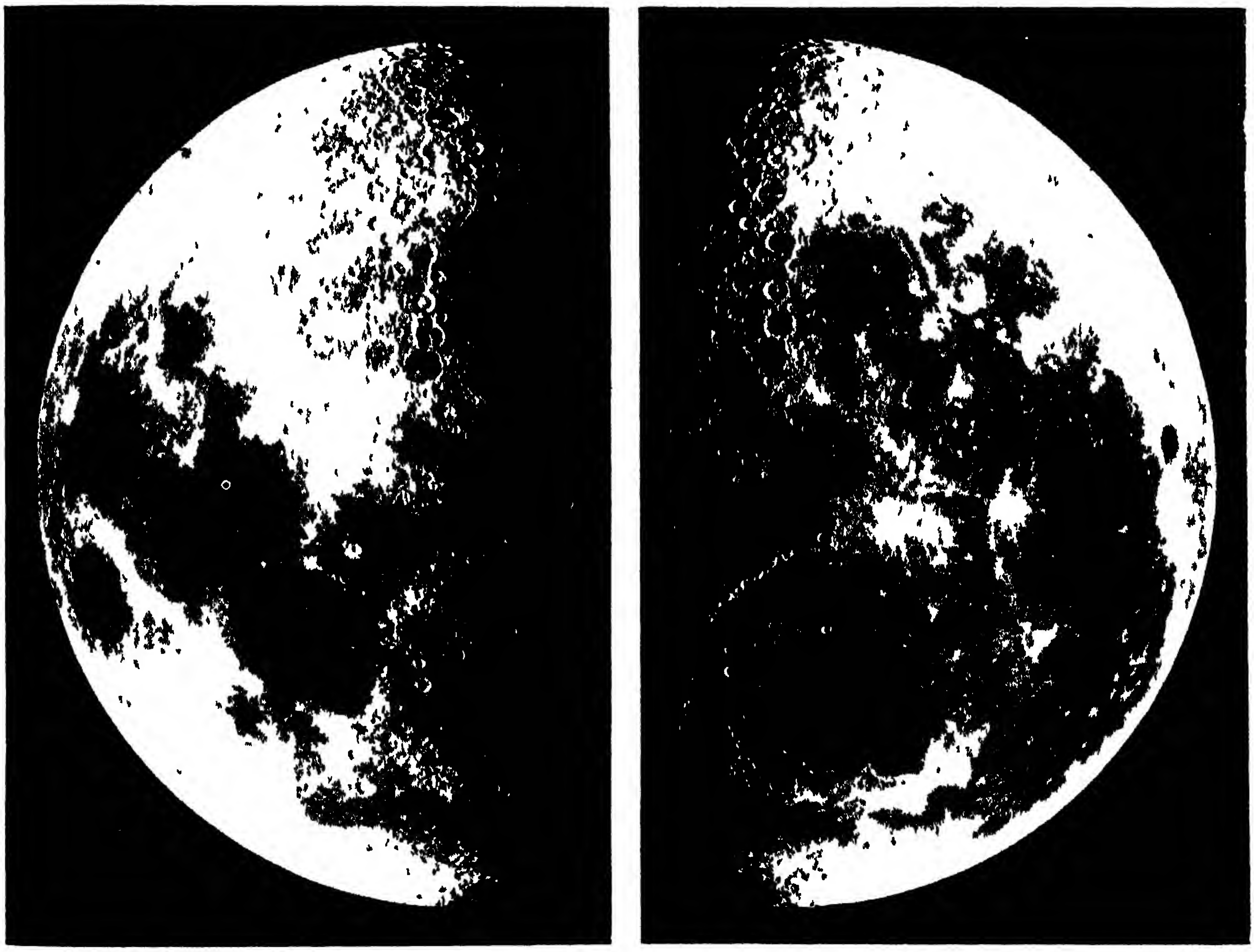
A SECRET of astronomy which is known to all, even to savages and little children, is that the Moon has phases; that is, that its face changes in appearance. Sometimes it is a round disc of light, sometimes it is a mere crescent, and it has various shapes in between these two phases.

It is astonishing how many people there are to-day, even those who claim to be educated, who have not the remotest idea why the Moon thus changes its face as seen from the Earth.

The true explanation was found out by the Greeks. One of these, Thales, noted somewhere about six hundred years before Jesus was born that the Moon received its light from the Sun; and rather more than three centuries later another Greek scientist, Aristarchus of Samos, discovered that at the moment when the Moon was half lighted up the Earth was exactly opposite the dividing line between light and darkness, while the direction of the Sun was at right angles with the line between the Earth and Moon.

Centuries later, when the telescope had been invented and the great Galileo looked at the Moon through his telescope, he noticed that the boundary between the dark part and the light was not an even line but an irregular one, and from that fact he drew the conclusion that the Moon was not a perfectly smooth sphere.

Of course, the reason for the phases is that the Moon is an opaque body which shines only by reflected light from the Sun. When that side of the Moon upon which the Sun is shining faces the Earth directly, then have we



In these pictures we see the Moon as viewed through an astronomical telescope, which means it is inverted. On the left the Moon is shown nine days old, that is, nine days after New Moon, and on the right it is twenty days old, that is, six days after Full Moon. To see these pictures of the Moon in the corresponding positions as viewed with the naked eye they should be turned upside down. The dark patches are the so-called seas, and many of the craters can be identified by means of our Moon map on page 310.

the fine spectacle of a Full Moon in the sky. On the other hand, when the dark side is turned towards the Earth we do not see the Moon at all. It is at the phase called New Moon. People often call a Crescent Moon the New Moon, but this is not correct. The New Moon is invisible to us on the Earth.

The picture on the opposite page explains the matter clearly. We are supposed to be looking down on the Earth and Moon from Space, and the Sun is shining from the right. The outer ring shows what the appearance of the Moon is from this point of view. Half the Moon's surface is being lighted up by the Sun, and from our point in Space we see half the disc luminous.

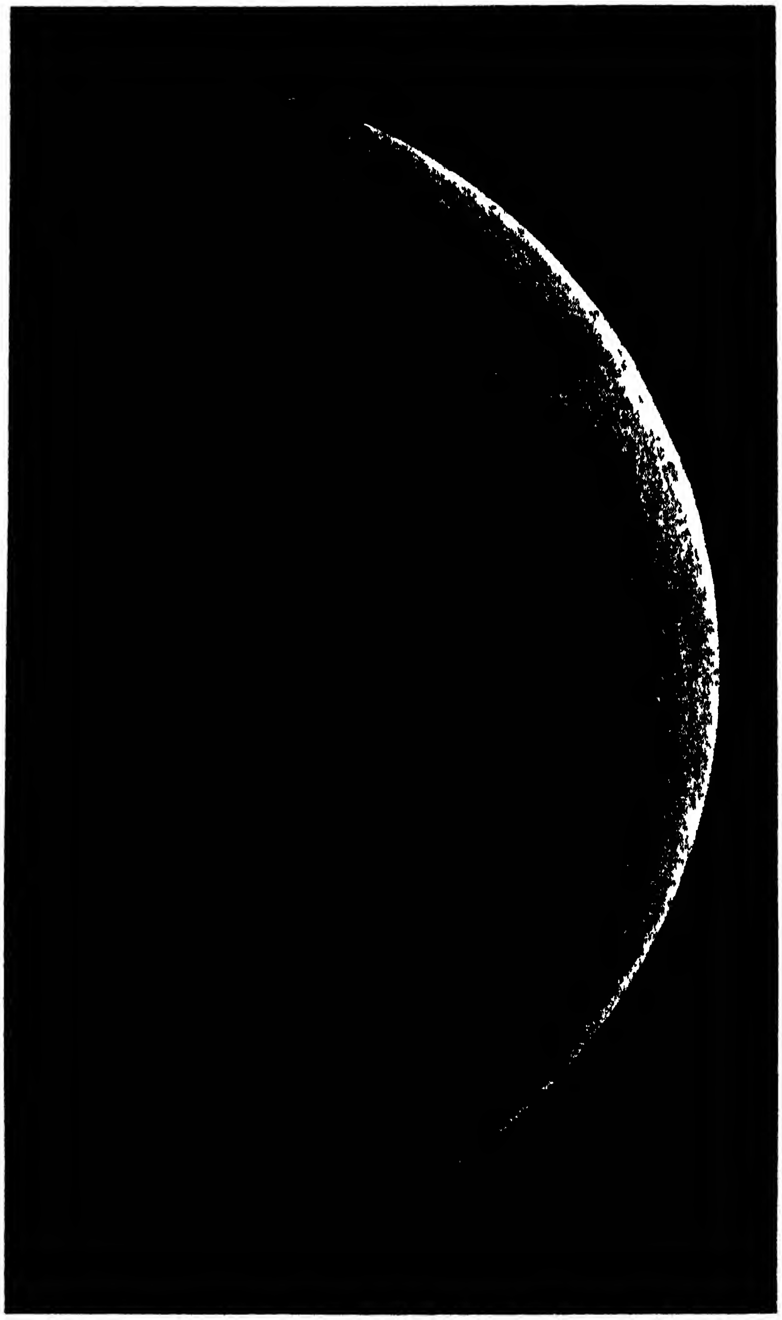
But viewed from the Earth, of course, the appearance is different. What the Earth sees of the Moon when it is in these different positions is shown by the inner ring of Moons. A little thought and careful examination of the picture diagram will make this clear.

A Good Experiment

If we have any difficulty we can carry out a simple experiment which will help us greatly. Let us take a small ball and place it ten or twelve feet from a very bright light, the light being concentrated upon the ball. We can do this with an electric hand lamp in a darkened room, or with the dazzle light of a motor-car outside on a dark night.

Half the ball will be lighted up, the light representing the Sun of our diagram and the ball the Moon. Now if we move round the ball and view it from different points we shall get a very similar effect to the phases of the Moon as seen from the Earth, and we shall understand why sometimes we see only a bright crescent, at other times half a Moon, at other times a fully lighted disc, and so on.

When only the crescent is visible we call this the Crescent phase. When half the disc appears illuminated we call this the Half-moon. When all the disc is illuminated we say it is Full Moon. There is a phase when more than half the disc is bright, and this is called by scientists the Gibbous phase. The name comes from the Latin word "gibbus," meaning a "hump," and it was given because in this phase the Moon looks humped.



The Crescent Moon twenty-six days old, as seen through an astronomical telescope, that is upside down according to our normal view

The line which separates the dark portion of the Moon's disc from the bright is called the terminator.

It is interesting to look at the Moon near the time of New Moon, for then, although only a crescent is shining brightly, we can by looking carefully, see the portion of the Moon on which the sunlight does not fall. It has a pale reddish colour, and it is seen by earthshine, that is, by light received by the Earth from the Sun and reflected back upon the Moon. The Earth, as seen from the Moon at this time, is nearly full. It must be remembered that any dweller on the Moon would see the Earth showing all the phases that the Moon does.

It is believed that the earthshine by which the Moon is illuminated is from fifteen to twenty times as strong as the moonshine of the Full Moon. The reddish colour of the earthshine on the Moon's surface is due to the fact that the Sun's light has twice passed through the Earth's atmosphere, thereby acquiring a sunset tinge.

The Crescent Moon can never appear high up in the sky late at night, nor, of course, can a Full Moon ever appear on the same side of the heavens as the setting Sun. Artists sometimes make mistakes of this kind when painting moonlight scenes.

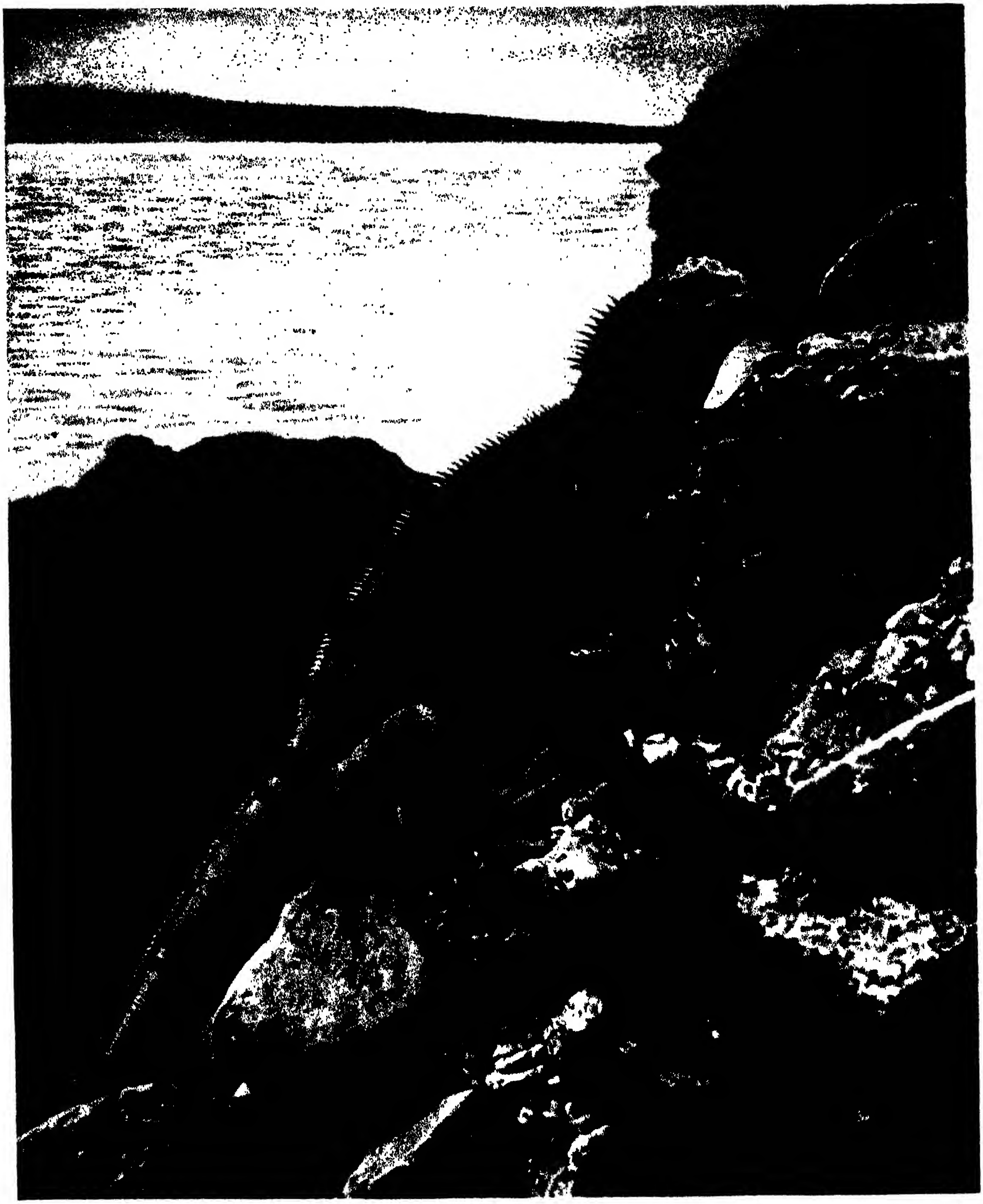
Of course, now that we understand the phases of the Moon we know that stars can never appear inside the cusps or points of the Crescent Moon as they are shown in the national flags of Turkey and Egypt.

Changing Positions

In spring and autumn, when the Sun sets in a line which is much more perpendicular than it is in summer or winter, it shines up as it were on the underside of the Moon, as viewed from the Earth, and we have the curious effect of the Crescent Moon lying on her back, as it is called. In summer and winter, when the Moon goes down toward the horizon along a much more slanting path, the Crescent Moon appears in a far more upright position.

The Moon's path round the Earth is not a circle but an ellipse, and so the Moon is sometimes nearer to us than at others. It makes the complete journey round the Earth in 27 days 7 hours 43 minutes 11½ seconds.

"PREHISTORIC MONSTER" THAT STILL LIVES



In the Galapagos Islands, 700 miles out in the Pacific from the coast of Ecuador, cut off by some great volcanic upheaval in the reptilian age of evolution, forms of life survive which have died out elsewhere. The great marine iguana shown above is one of these. Larger than the yellowish land iguanas (*see* page 485), these giant lizards are over 4 feet long, and their blackish colouring blends with the dark rocks on which they sun themselves. The marine iguana feeds on seaweed on the shore and in the sea, swimming strongly by means of its flattened tail. A mild creature (unlike the fierce land iguana), it can stay under water for at least an hour

To face page 481

MAN MAKES FRIENDS OF THE ANIMALS

The domestic animals have been man's greatest friends. They have helped him in cultivating the Earth, in travelling over its surface, and in capturing other creatures for his food. In these pages we read something about the way in which man probably first came to domesticate such animals as the dog, the cat and the horse

Long ago, before the beginnings of history, man began to make friends among the animals and to train them to help him in his fight with Nature.

Without the help of such animals as the horse and ox and ass it would have been quite impossible for man to have practised agriculture on anything but the smallest scale, and as a consequence he would have been compelled to remain scattered about the Earth. It was only when he had tamed the ox to pull his plough and the horse and ass to act as beasts of burden that large crops could be grown and gathered and transported, so as to make it possible for thousands of people to live together in one place.

Exactly how man tamed the animals we do not know, but that he did so early in his history is proved by the fact that we find the remains of domestic animals in the rubbish heaps of the Stone Age.

Probably the very first animal to be domesticated was the dog. Wild dogs are found in many countries to-day and among the different kinds are the wolf and the jackal. Exactly which were the ancestors of our modern domesticated dogs cannot be decided with any certainty, but men of science believe that the chief, if not the only ancestor, was the wolf, although some think the jackal had something to do with the matter.

When man lived by hunting, and his diet consisted entirely of the flesh of the animals he caught in the chase, such animals as wolves and jackals would sneak round his home on the look out for the remains of the carcasses. Possibly among the animals thus seeking for food were some young wolf cubs, which may have been captured by Stone Age children in sport, to be made pets, and these, finding that the children shared their food with them, loitered in the settlement and became attached to their human masters.

When they were full-grown the pet wolves would probably accompany the men on a hunting expedition, and as they proved useful the idea came that young wolves might be trained to assist man in his hunting.

But after a time it was not necessary to capture young wild wolves. Those which had already been tamed had litters of cubs, and these were trained to help their masters. They would assist them in the chase, they would by their barking give warning of the approach of enemies, and they would help in the fight against different foes.

In some such way man obtained his first animal helper. He taught it no

It is almost certain that the first animal to be domesticated by man was the dog, or rather its probable ancestor, the wolf. Perhaps Stone Age children in sport captured little wolves to make pets of them, and these, finding that the children shared their food with them, remained with the human family and became attached to their masters and mistresses

longer to fear the fire, as do all wild animals, and we know, from our pet dogs, how thoroughly changed its character has become in this respect, for the domestic dog to-day loves the fire and likes to lie in front of it.

The dog has lived so long in the company of man that it is the most completely domesticated of all the animals. It is the greatest friend man has and becomes more attached to him than any other animal.

Possibly, too, in a similar way, the cat was domesticated. Wild cats of some kind are found in most parts of the world, and possibly woman was the tamer of the cat as man had been of the dog. Woman was, it is believed, the first agriculturist, and when she began to grow crops and harvest the grain, storing it for use in the dark days of winter, this would attract hordes of rats and mice. These in their turn would attract wild cats, and probably one day some kittens were caught by the women, who found them amusing and attractive pets. They were brought up and became domesticated like the dog, though they never became so friendly or attached to their owners as the dogs.

There are wild cats in Scotland to-day, but these are probably of a larger breed than the wild cat which was first domesticated.

In a grain-growing country like Ancient Egypt the cat was of very great importance in keeping down the mice that preyed on the corn, and it is perhaps not surprising that the Egyptians came to associate it with their religion. Just as they preserved the bodies of their human friends with spices, so also they made mummies of their cats, and thousands of these mummy cats have been found in the tombs of Ancient Egypt.

Even in Great Britain in the past the cat has been regarded as being of much greater importance than it is to-day. Nearly a thousand years ago in Wales a law was made for the protection of the cat. This law fixed a price for all kinds of cats, starting with the amount to be paid for a newly-born kitten before it had its eyes open.

The Price of a Dead Cat

Then it mentioned the punishment for anyone who stole or killed a cat which was guarding the corn of a prince. If the thief were found he was to pay a sheep and a lamb, and if he had killed the cat the animal was to be hung up by its tail with its nose touching the floor and the culprit would then have to hand over as much wheat as, piled up on the floor, would cover the cat to the very tip of its tail.

We do not know the order in which the other animals were tamed, but probably the ox came next. It would be a very useful animal, for it provided large supplies of milk, it would help to pull the plough, and when killed its flesh would form welcome food. In mountainous country, where it was difficult to keep cattle, the goat would also prove very useful as a supplier of milk and meat.

Then would come the horse. In those early days wild horses lived in different parts of the world, and no doubt their speed was greatly admired by men who wished that they themselves could run as fast when chasing animals for food.

One day a particularly able and strong young man would seize a young horse by its mane and run with it, and, greatly daring, he may have sprung upon its back and thus found that the animal could carry him.

Starting with young colts, men began to train the horse as a beast of burden, and thus tamed one of the most valuable of domestic animals.

Wherever he has gone man has taken the horse and the dog with him. But while the dog can live in all climates, the horse thrives only in temperate countries. It is no use in the Arctic or Antarctic, but

It was a great step forward when man captured the wild horse, and trained it to obey him. Probably some strong young man seized a horse by its mane and running with it sprang upon its back, and found that the animal could carry him. It would be difficult to over-estimate the service which the horse has rendered to mankind

there strong dogs are used for drawing sledges loaded up with goods.

In practically all countries there are beasts of burden; indeed, life would be almost impossible without them.

Taming the Ass for Use

A relation of the horse is the ass, which is quite swift and is more surefooted. It was tamed at a very early stage in man's history and proved even more useful than the horse in some lands, for it can live on pastures so poor that a horse could not survive. In the countries round the Mediterranean, where grass is scanty and the country hilly, the ass is a very valuable animal.

In South America, when the Spaniards went there, they found the natives had tamed and brought into use a relation of the camel known as the llama. It was this that made South America a much more thickly-populated country before the white man went there than North America, for in North America there was no beast of burden, and probably the whole population was less than half a million. Now it is much more than a hundred millions. In the dry desert lands of Africa and Asia, where horses and asses could not live, man found another animal which he domesticated—the camel. It is not a very friendly animal, but probably in the first case men took very young camels. The animal has a large, flat foot which does not sink into the loose sand as would a horse's hoof. It is slow but strong, and can travel long distances without water. By a special arrangement of Nature it is able to store up water and also nourishment in its body. In the countries where it lives it is the most valuable of all domestic animals.

Sheep for Food and Clothing

Sheep have also been domesticated from an early period. Possibly it was their wool which first attracted women, who found that by cutting it off they could get a warm material which they learnt to spin and weave. Then the wool grew again on the sheep, and when the sheep was killed its flesh proved an attractive food.

The pig, which is a domesticated variety of the wild hog, is the only animal that has been domesticated purely for food purposes. Its skin, however, can be tanned and provides a tough leather. But, of course, early man knew nothing of leather. It was the skins with hair or wool on, like those of the ox and sheep and goat, that he found useful for clothing and warm covering

The High Road of Progress

Very early in his history, too, man began to domesticate the hen, keeping it chiefly for its eggs, and later other birds such as the duck and goose and guineafowl were kept for the same purpose.

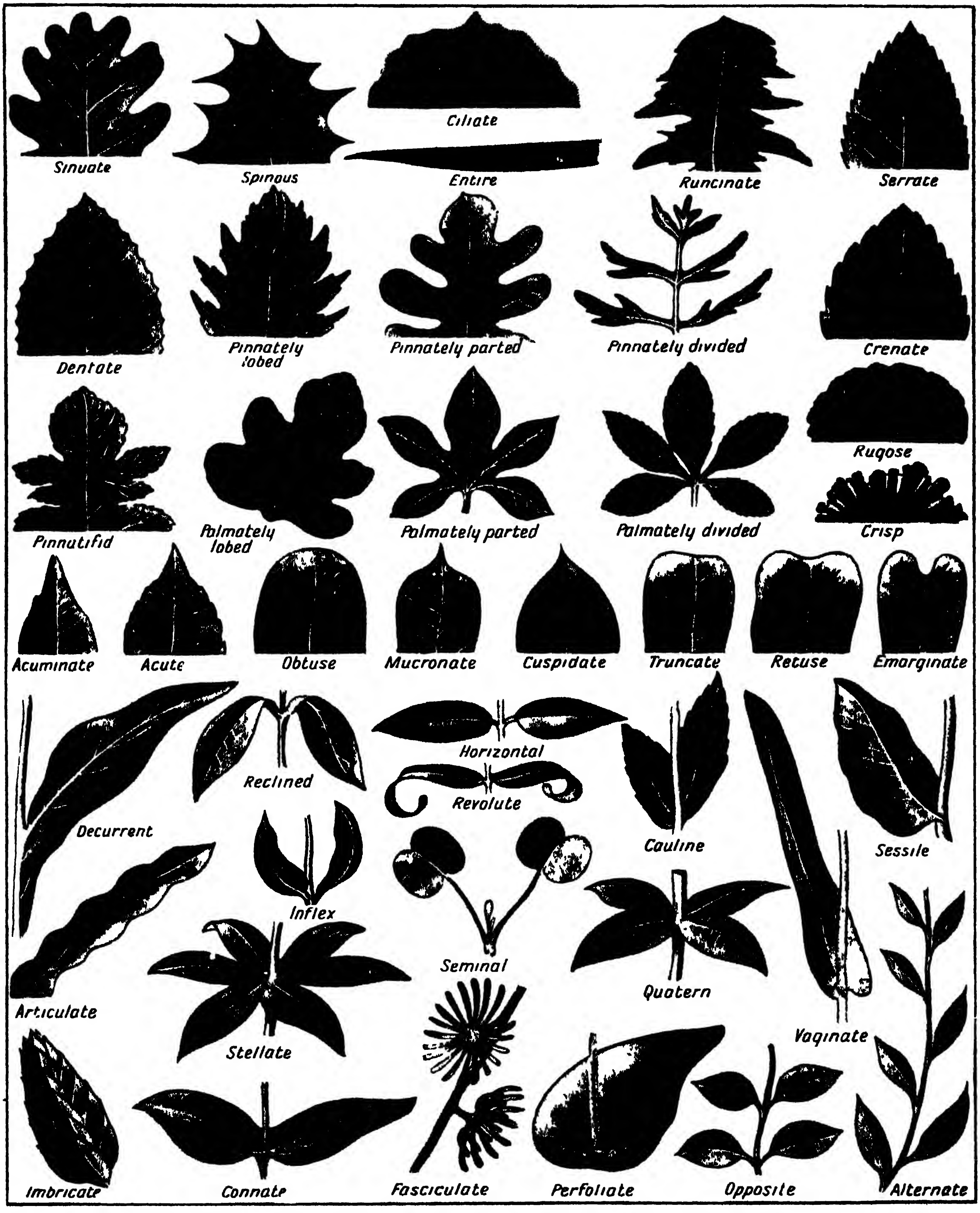
This domesticating of animals by early man greatly increased his ability to survive. Before, he had been in constant danger of starvation, but now, with a supply of animals available for food, he was no longer so dependent on luck in hunting.

It is really the taming and training of the animals to do his work and serve his purposes that set man on the great high road of progress. He is less dependent on the animals to-day than he has been for thousands of years, but without the ox and the ass and the horse and the sheep and the dog man would certainly never have reached the pitch of civilisation that he has attained to-day.

AN OWL THAT WILL FEARLESSLY FIGHT A MAN

This photograph shows the head of the snowy owl, one of the most interesting members of its family. Its plumage is white, with spots and bars of black or dark brown, and it is found in northern countries, like Siberia, Northern Russia, Scandinavia, Greenland, Iceland and North America, where it lives on lemmings, Arctic hares, ptarmigan, grouse, ducks, young sea birds, and sometimes the Arctic fox. When the lemmings migrate snowy owls follow and prey upon them. The snowy owl is from 22 to 27 inches long, and when its nesting-place is approached the male becomes very ferocious. People of those parts sometimes seize a young bird, and when the parents fly at them, hold up a gunstock, against which the birds dash themselves headlong till they are killed or beaten off. The natives of the Arctic regions are very fond of the snowy owl's flesh as food

THE MANY DIFFERENT OUTLINES OF THE LEAVES

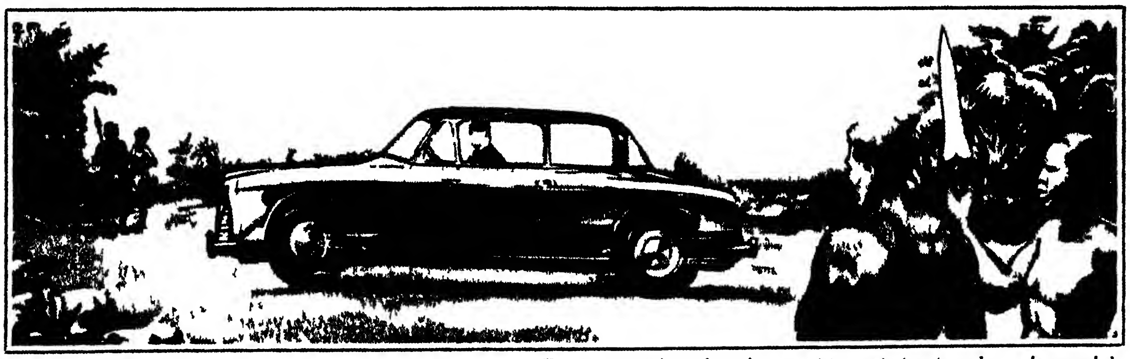


Botanists have classified the leaves according to their margins and their tips, and in this page we see the different forms and their names Sinuate means "wavy-edged", Ciliate, "fringed with hairs", Runcinate and Serrate, "saw-like"; Dentate, "toothed", Pinnate and Pinnatifid, "like a feather"; Crenate, "notched", Palmate, "like a hand", Rugose, "wrinkled"; Acuminate, "sharpened"; Mucronate, "sharp-pointed", Cuspidate, "pointed", Retuse, "blunted", and Emarginate, "notched" The lower pictures shows different ways in which the leaf is attached to the stem Decurrent means "running-down"; Cauline, "belonging to the stem"; Sessile, "sitting", Inflex, "incurved", Seminal, "seed-like", Vaginate, "sheathed", Imbricate, "overlapped"

A LIVING DRAGON LOOKS OUT OF ITS LAIR

This striking picture shows one of the land iguanas of the Galapagos Islands It is a stoutly built lizard with a comparatively small head and the body has a spiny crest along the back The limbs end in short toes with sharp claws The tail is longer than the head and body together, and the whole animal is about three feet long and weighs from ten to fifteen pounds In this photograph the iguana certainly looks like one of the prehistoric monsters of a past age There is really nothing by which we can judge its size The whole picture is indeed an interesting example of relativity If a boy or girl had been taken in the photograph by the side of the iguana, then the animal would have appeared its true size These iguanas live in burrows and are very sluggish in their movements At every few steps they stop for a minute or two and doze with closed eyes They feed by day on the succulent cactus of their native haunts, and on leaves of trees, climbing the trees for the purpose The females lay large eggs People in the Galapagos Islands eat their flesh

A STRIKING ILLUSTRATION OF RELATIVITY



In this picture a motorist is seen in Uganda, somewhere near the Equator, speeding along from east to west at sixty miles an hour, while the natives look on in wonder There seems no doubt about the motorist s speed or his direction He passes like a flash Yet it is just as true to say he is moving in the opposite direction, and at a much greater speed than sixty miles an hour This may seem a paradox or puzzle but the picture below will explain the matter It is all a question of relativity, as we shall see

In the upper picture the motorist s speed and direction are relative to the Earth's surface But suppose we could leave the Earth and go out into space and watch the motorist He would not from that point of view be seen travelling at sixty miles an hour from east to west, but would be moving at about 940 miles an hour from west to east Why the difference ? Well, the Earth at the Equator is rushing round in the direction shown by the arrow at about a thousand miles an hour, and as the motorist is travelling over Africa in the opposite direction at sixty miles an hour he would really be carried with the Earth in the direction it is travelling at 940 miles an hour

SIMPLE FACTS ABOUT RELATIVITY

Relativity is a word that has come to stay, and it describes a scientific fact which is of great importance. All intelligent people, including boys and girls, should know something about it, and in these pages it is explained by word and picture. This great fact about it is that any statement we make about the Earth or the Sun or the planets or the stars, or Time or Space, are only relatively true, that is, they are only true when thought of in relation to something else. Two statements which appear to contradict each other may both be true

A WORD that is much heard in these days is Relativity. It is an old word which has been used for a hundred years, and it means the state of being related to something. It is only in the present century, however, that Relativity has come to be a common word that constantly occurs in lectures and books and even in ordinary conversation.

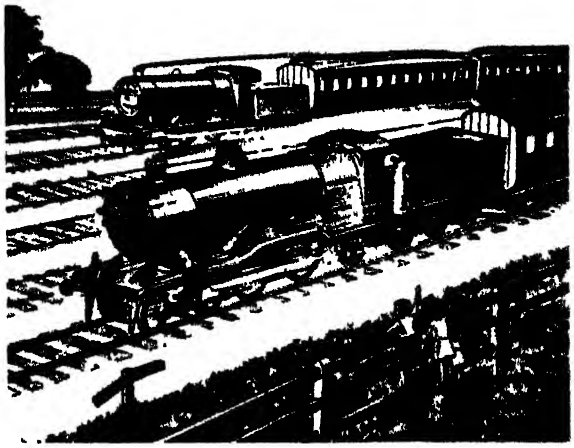
Newton and Einstein

This is because men of science have thought out or discovered something new in connection with the system of the universe, and the man whose name is most generally associated with the term Relativity is Professor Albert Einstein.

The Englishman Sir Isaac Newton, one of the greatest scientists who ever lived, discovered certain laws about the universe which, until the early part of the twentieth century, were considered to tell the whole truth about these matters. But as scientific instruments became more delicate and intricate, and men of science were able to carry out their experiments with greater accuracy, it was seen that certain happenings, as, for instance, the behaviour of light in its journey through Space, and gravitation or the attraction which the heavenly bodies have for one another, did not always seem to conform to Newton's laws. For a long time these discrepancies were a great puzzle.

The Possibility of Error

Of course when, during a scientific experiment, things do not happen quite as they are expected to do, there may be some mistake or slip in carrying out the experiment. But when the same thing happens again and again, as the experiments are carried out by different scientists using different apparatus in different parts of the world, then it is felt that there may be something wrong about the law as it is understood. This has happened in recent years, and what Relativity really means is this: that certain things, as for example the speed of light, the pull of gravitation, the form of the universe, and so on, are true only relatively, that is, when considered in relation to something else.



These two trains are travelling at sixty miles an hour, and the children on the fence see them flash by at this speed, which is relative to the ground over which they move. A passenger in either train, however, looking out at the other, would see it motionless, so far as he was concerned, that is, the relative positions of the two trains would not change at all

To go into this matter fully is quite impossible in simple language; only those who have studied the higher mathematics can grasp the details of Relativity, but we can all understand something of how this principle affects the universe in which we live.

A Relative Truth

Let us take one or two simple examples. We are sitting on a seat on a railway platform and we see the Cheltenham Express or the Flying Scotsman rush by at sixty miles an hour. It is gone in a flash, and we should probably say that while we are at rest on a stationary spot, the train is travelling at an enormous speed. But is this true? Certainly it is true so far as we are concerned, that is, relative to ourselves and our position the train is travelling at sixty miles an hour.

Anyone standing on the ground and seeing this train flash by would say the boy and girl were travelling at sixty miles an hour, but anyone in the carriage would say that they were sitting still, and that the telegraph poles and other things outside were flashing by at sixty miles an hour

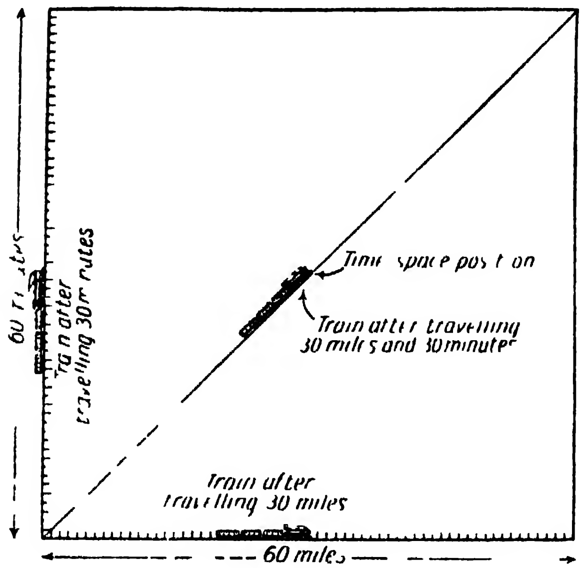
The Other Point of View

But suppose we are sitting in the train and looking out of the window. We are comfortably resting on the seat and not exerting ourselves or moving our limbs in any way. Suddenly as we look out of the window a station flashes past. It has come and gone in a moment, and then one after another, succeeding each other like the palings of a fence, the telegraph poles pass before our eyes. We say to a travelling companion in the same carriage, "What was that station that flashed by?" or "Look how the telegraph poles rush past!"

Is this true? Are we stationary and the railway station, the telegraph posts, the houses and the fields all flying past at sixty miles an hour? Certainly it is true, so far as we are concerned, that is, relative to us, these things are travelling past at a great speed.

Now what are the true facts? Is the train travelling rapidly over the ground or is the ground travelling rapidly under the train? Both statements are true and one is no more true than the other.

If a person could view the train and the Earth through a telescope from a distant planet he might see the train quite stationary and the Earth whirling round under it. On the other hand he might see the Earth stationary and the train rushing round it. Or yet again he might see both in motion, the Earth travelling one way and the train travelling another.



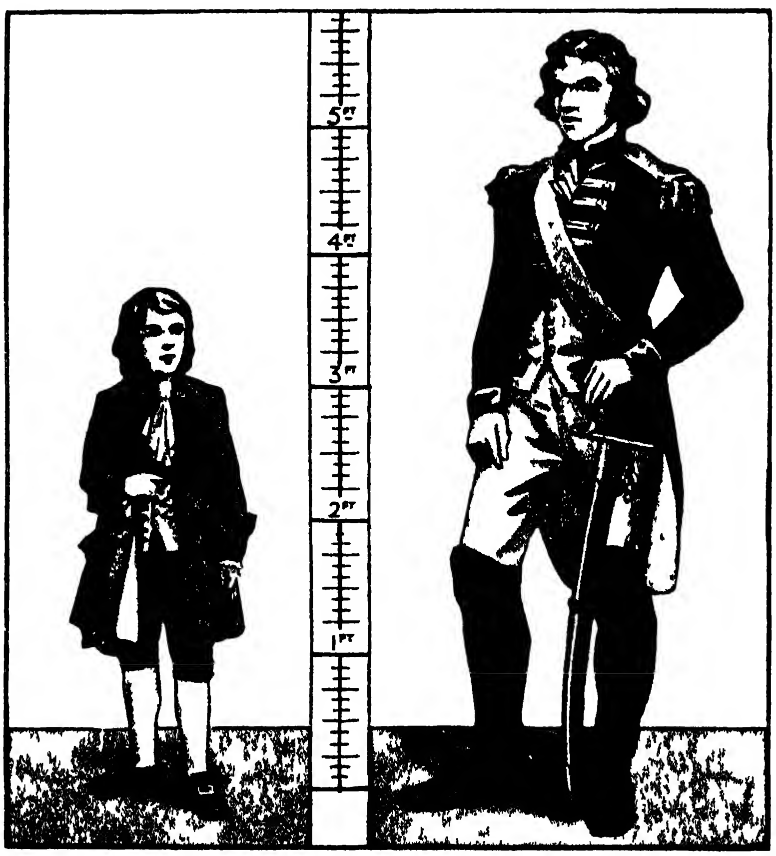
In this diagram we see on the horizontal line the position of a train travelling at sixty miles an hour after it has travelled thirty miles. We see also on the vertical line the position of the train represented graphically, after it has travelled thirty minutes. If we want to show its position both in space and time after travelling thirty miles in thirty minutes we should have to show it on the slanting line. It is an example of Relativity shown graphically.

Time and Space

It is all a question of Relativity. It depends on the point of view, and not only the point of view in space but the point of view in time.

This reference to time may seem strange, but here again if we think a little we shall see its importance. Let us take an example showing the importance of time which can be understood even by the youngest.

If the question were asked how big was the Duke of Wellington a perfectly truthful answer might be: He was 3 feet 9 inches high and weighed 36 pounds. But somebody else might laugh at this answer and say that the true answer was that the Duke was 5 feet 9 inches in height and weighed 11 stone. These two answers seem perfectly contradictory, but they can both be true. To make them correct answers we must bring the time element in. That is, we must say that the Duke of Wellington was 3 feet 9 inches high and weighed 36 pounds in 1776, and that he was 5 feet 9 inches high and weighed 11 stone in 1796.



These pictures of the Duke of Wellington illustrate Relativity. If we were asked how big he was we might say he was three feet nine inches high, and weighed 36 pounds. But someone else might say he was five feet nine inches high, and weighed eleven stones. Both statements would be correct, but only relatively. The time element must be brought in, and we say the Duke was three feet nine inches high in 1776, and five feet nine inches in 1796.

The New Star

Let us take another example. Every now and again as astronomers watch the heavens there shines out suddenly a new star which has never been seen before and after getting brighter and brighter for a time it gradually fades away and disappears.

A notable example of this occurred on February 21st, 1901 when in the constellation Perseus, a new star was first seen. It appeared about as bright as the Pole Star. It gradually increased in brilliancy and on February 22nd was for a few hours the brightest star in the heavens with the single exception of Sirius the Dog Star. Then its brilliancy gradually grew less till by the end of March it was barely visible to the naked eye.

When Did It Happen?

This sudden appearance of a star with increasing brightness for a time followed by a fading away tells us that something tremendous has happened away in Space, though we cannot be sure exactly what it is.

Now to return to our question of Relativity. One astronomer might say that this new star which was called Nova Persei, meaning the New Star of Perseus, occurred in the twentieth century, and another astronomer that it occurred more than 300 years ago.

What is the explanation of the apparent contradiction? It is a question of Relativity. Relative to ourselves and the astronomers who were watching on the Earth the sudden breaking out of this star occurred on February 21st 1901, but from the point of view of an imaginary person situated where the star actually was it occurred all those millions of years ago, because it is so inconceivably far away that its light took that time to travel to the Earth. Both statements are correct, but neither is true in the absolute sense apart from its relation to something else.

Many Instances

If we think carefully we shall remember many instances where Relativity comes in. How often we have sat in a train and looking out of the window have seen another train travelling in the same direction as ours, but not so rapidly, and have had the illusion that the other train was going in the opposite direction! And so it was relative to our train, but as we look

out and notice the telegraph poles and trees beyond, we see that while it is going in one direction relative to us, it is going in the other direction relative to the stationary things by the side of the line.

On a sunny day we notice that the Sun moves across the heavens from east to west, and it is not surprising that the men of old time used to say that the Sun moved round the Earth. We know now that the Earth moves round the Sun, and that the Sun appears to go across the sky because the Earth itself is turning round on its axis from west to east.

Our Path Through Space

Here again it is a question of Relativity. From our point of view, as we stand on the Earth and look up, the Sun moves across the sky; from the point of view of a beholder who might be looking from a distant star in Space, the Earth is travelling round the Sun.

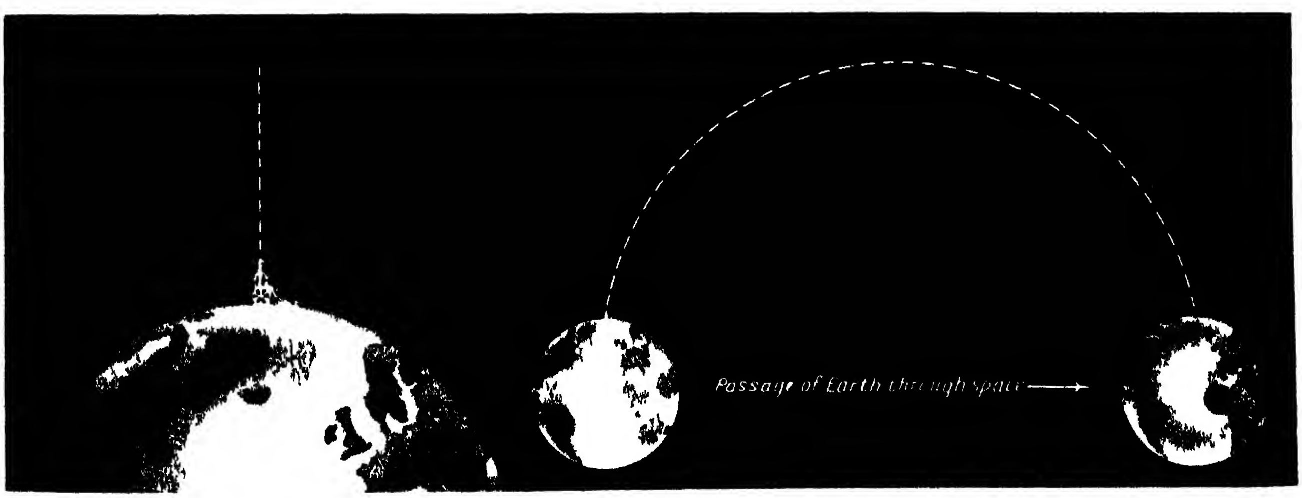
Considering the Solar System alone, we know that the Earth goes round and round the Sun in an ellipse, coming back each year to the same position. But seen from outer Space the Earth's journey round the Sun is by no means an ellipse, as we see from the picture on page 43, and so far from coming back to the same position after a year the Earth's position is really many millions of miles from where it was a year ago.

Position is a question of Relativity. As we stand in England with our feet on the ground looking up at the Pole Star, we feel that we, like other people, are standing upright. But we remember that our kinsmen in Australia and New Zealand on the other side of the world have their feet nearest to us, and if we could see through the Earth they would appear to be hanging head downwards. But on the other hand, from their point of view they are standing on the Earth upright, and if they could see through the Earth we should be hanging head downwards, while to both of us people in India and Rhodesia would be standing on the Earth at right angles to ourselves.

What Is Size?

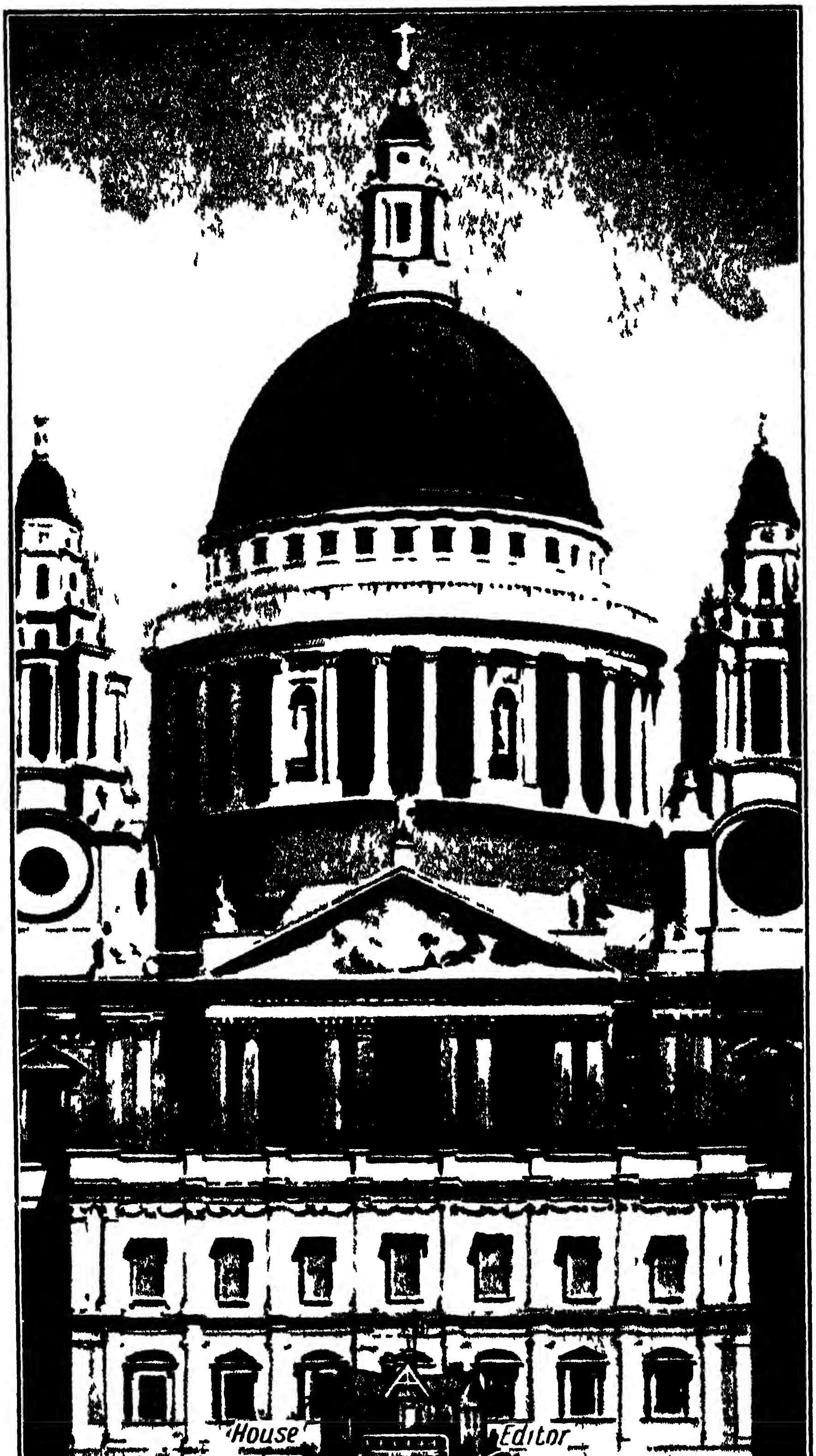
Then again take bigness. Nothing is large or small absolutely, but only in relation to other things. A fly is small compared with a boy, but a boy is little compared with an elephant, and an elephant is small compared with St Paul's Cathedral. St Paul's is very tiny compared with Mount Snowdon, and Snowdon is very small compared with Mount Everest. Compared with the Earth Mount Everest is a mere speck, and the Earth itself would appear

In these two pictures we have an example of Relativity. The barge, with the man on board, is travelling from right to left, and we can see that relative to the watcher on the bank its position is different in the second picture from the first. The man on the barge, however, has travelled with it, but as he has been walking along the barge from left to right his position relative to the tree and the bank and the watcher by the fence has not changed.



If a gun were pointed vertically upwards and a shot fired exactly perpendicularly so that it went up and came down, re-entering the muzzle of the gun, its path as seen by anyone on the Earth would be as shown in the first picture. But as seen by anyone watching from distant space the passage of the shot would be very different. It would be as shown in the second picture, for the Earth would have travelled in its orbit and the shot, attracted by the Earth's gravitation, would have travelled with it so that its path would be something like the curved line shown. Both diagrams are correct but only relatively.

SIZE IS ALL A QUESTION OF RELATIVITY



The pictures on this page form an excellent illustration of the meaning of the term Relativity. On the left is St Paul's Cathedral in London with the Banqueting Hall Whitehall and various other things below all drawn more or less to scale. The very small white object little more than a dot is supposed to be the Editor's dog. Now the dog is big compared with a fly but it is small compared with the Editor who is seen standing by its side. The Editor seems big compared with the dog but he is very small indeed compared with the motor bus which is shown and the bus though big compared with a man is small by the side of the Editor's house. But the house is like a toy when placed in front of the Banqueting Hall and the Banqueting Hall seems very small when it is seen in relation to the great cathedral. Now look at the right hand picture. Here St Paul's is a mere speck when placed by the side of Mount Snowdon and Mount Snowdon is like a child's sand castle when seen in relation to Mount Everest.

All this shows that nothing is either large or small in itself but only in relation to something else. Everything is both large and small.

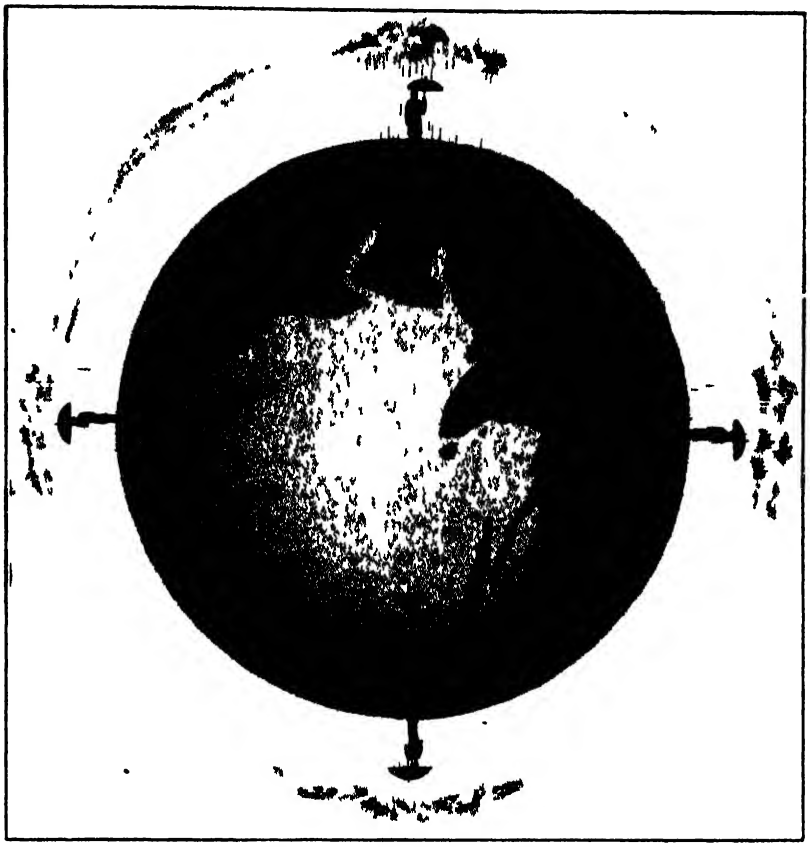
as a mere dot on the surface of the Sun.

We can only say a thing is large or small and only get any idea of size when we compare it with something else.

On the films sometimes a landscape with buildings and hills appears as though it were a great stretch of country because when looking at it we think of it relative to similar features on landscapes we know. As a matter of fact such scenes are often photographs of miniature landscapes arranged on tables in a room.

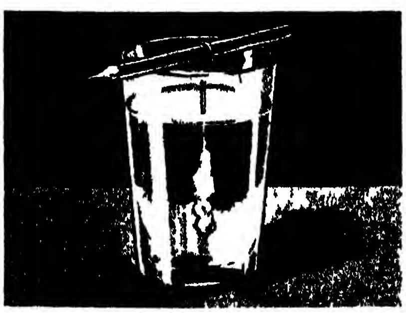
Finally Relativity comes even into moral matters. Goodness and badness are largely relative terms. Both have to be estimated relative to some standard. Killing a dog may be both good and bad. Good when it is to put the animal out of pain, or if it is meant to prevent it from hurting people, and bad when the killing is done out of sheer wanton cruelty. Children used to be taught that it was wicked to kill flies; now they are taught that it is good to do so. Formerly flies were regarded as harmless and to kill them was unnecessary. Now we know that the fly almost more than any other creature found in our country spreads disease and causes the death of little children. It is therefore good to keep down the number of flies.

We must never pride ourselves on our goodness by comparing our lives with the lives of people whom we regard as bad. We must remember that compared with people whose lives are very good we ourselves may appear bad. It is fortunate that in the case of goodness we need be in no doubt, for we have a splendid standard measure provided for us in the Sermon on the Mount and in the life of Jesus.

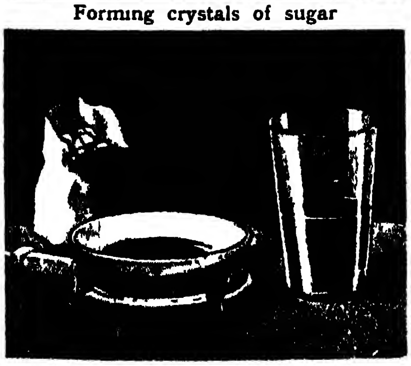


Does the rain fall up or down? Of course it comes down, you say. Yes, but only relative to yourself as it falls around you. If you could look through the Earth and see it raining in Australia, relative to yourself the rain would be coming up, though in Australia it would be falling down upon a man who, looking through the Earth, might see the rain falling up on you. It is all a question of Relativity.

SOME SIMPLE EXPERIMENTS WITH SUGAR



Forming crystals of sugar

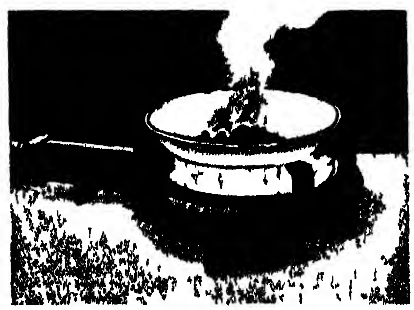


Making caramel from sugar

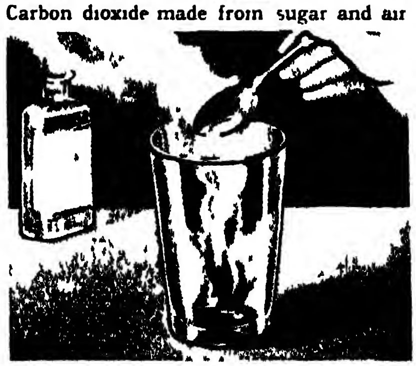
There are some interesting experiments which we can carry out with sugar. If we dissolve sugar in a glass jar of hot water till no more will pass into solution, and then suspend a string from a pencil laid across the mouth of the jar, we shall find after several days that crystals of sugar have formed round the string. Of course the warmer the room the faster the crystals will form.

If we put lumps of sugar into a saucer and heat it over a gas ring it will first melt into a clear liquid and will later change to a dark brown colour. In this state it is called caramel. If some of this caramel be dissolved in water the solution will be dark. When we continue heating the caramel in the saucer it will become very dark and catch fire, forming charcoal or carbon. Only a few lumps of sugar should be used. If the last experiment be continued the sugar will disappear, for the carbon will combine with the oxygen of the air and pass off as carbon dioxide gas.

If a teaspoonful of strong sugar solution be placed in a glass tumbler and a similar quantity of oil of vitriol or sulphuric acid be added, the mixture will at once turn black, froth up and give off steam and fumes. The black spongy mass which is left is carbon.

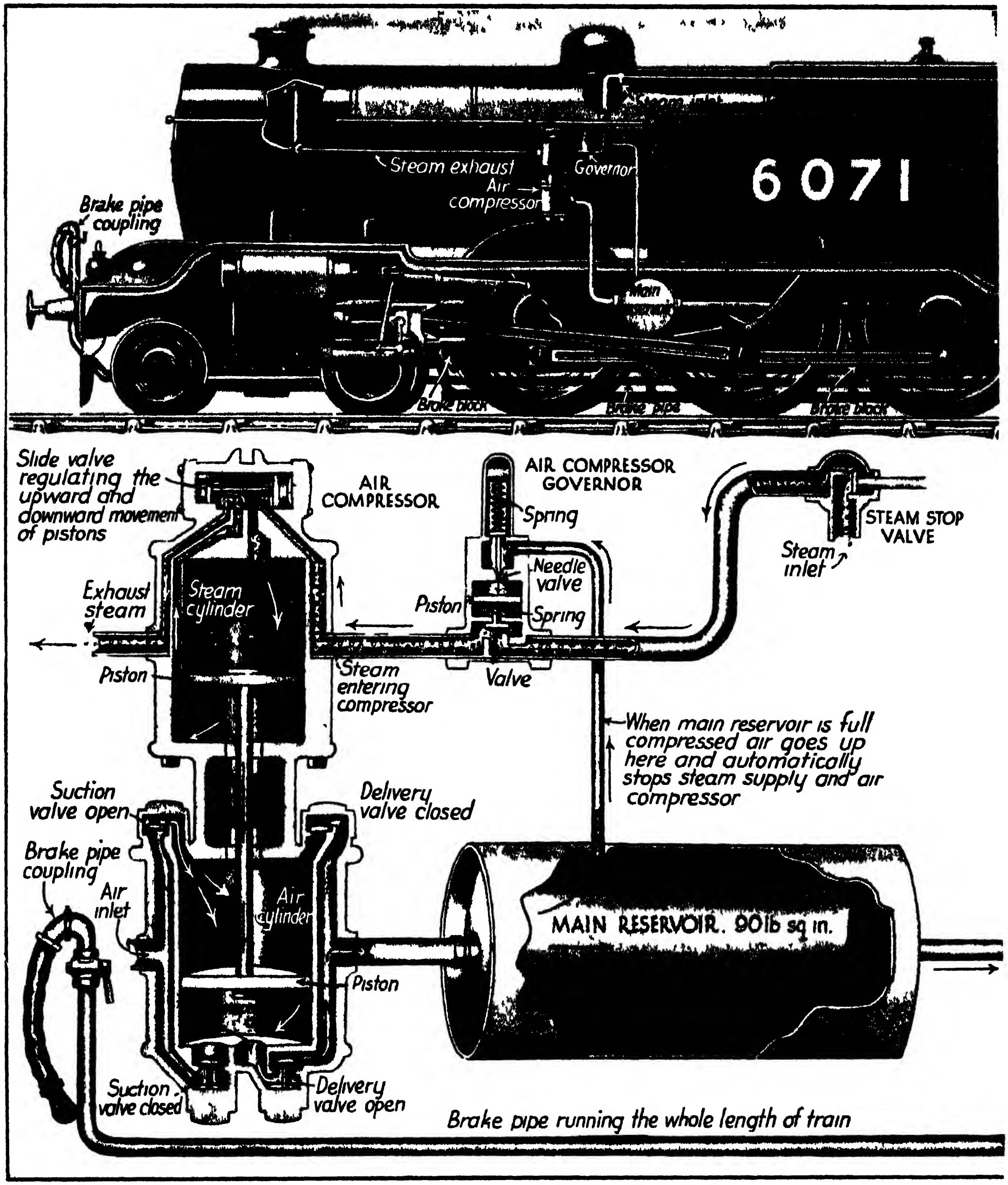


Carbon dioxide made from sugar and air



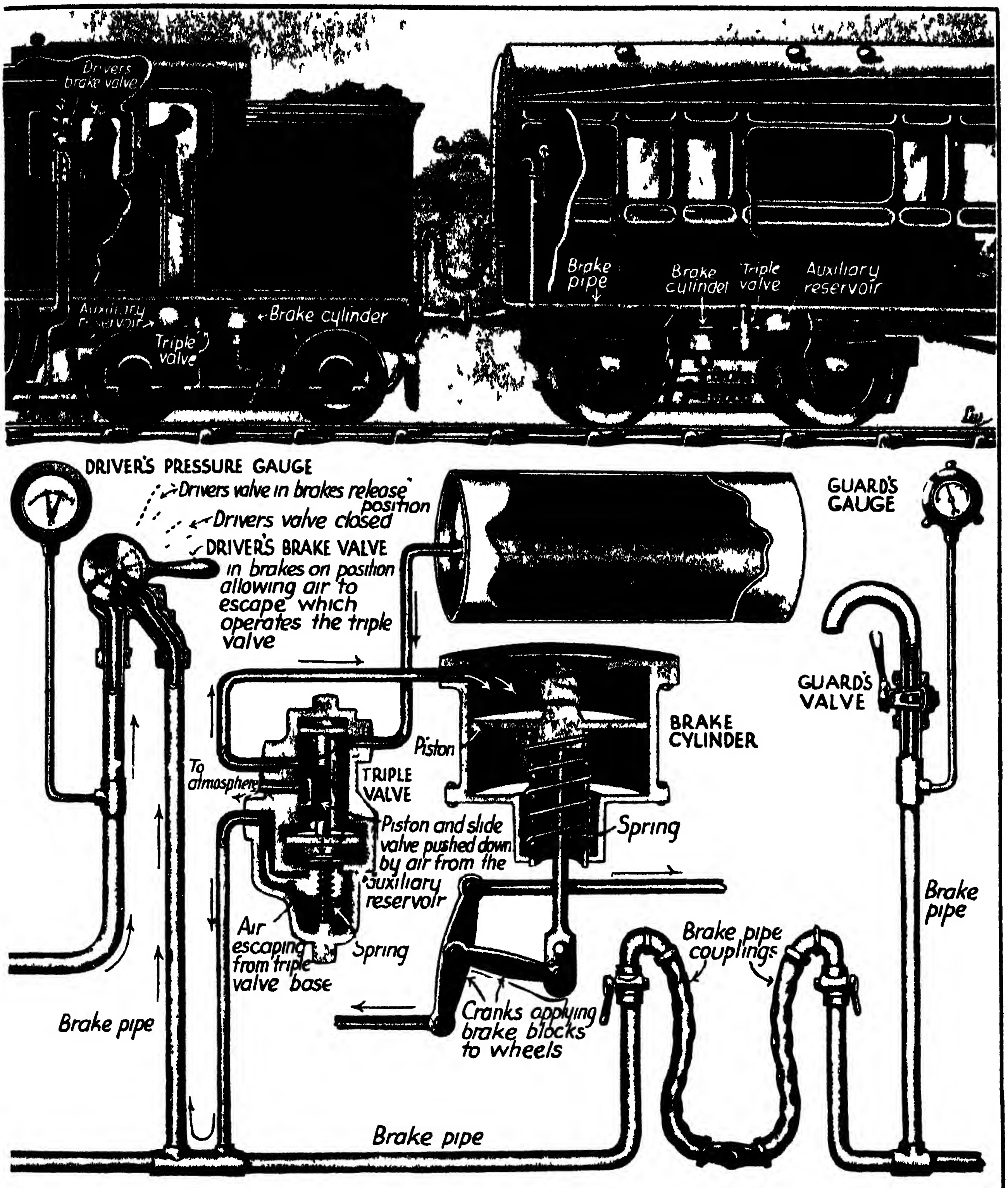
Generating heat without fire

THE WONDERFUL WESTINGHOUSE BRAKE



There are different kinds of brakes for stopping trains but the most efficient of all is the Westinghouse automatic brake, and in these pages we see how it works In the upper part of the picture we see a locomotive and part of a coach connected with it, and the positions of the different parts of the brake in relation to the train In the lower picture the parts of the brake are shown in detail and we see the inside workings The air is compressed by a piston worked by steam A steam stop valve admits steam from the locomotive for supplying the air compressor governor This is adjusted so as to cut off automatically the supply of steam when the desired pressure of air is reached by the air compressor as it compresses the air in the main reservoir This reservoir is connected directly with the driver s brake valve, through which the compressed air passes into the brake pipe also called the train pipe and thence flows through a triple valve into an auxiliary reservoir From this reservoir the compressed air passes to the brake cylinder so as to supply the brakes in the manner about to be described The hose couplings connect up the brake pipe, which runs the whole length of the train The connection of these various parts can be followed in both the upper and the lower pictures above The brake is applied by the engine-driver turning a tap which reduces the air-pressure in the brake pipe, and at once causes the pistons of the triple valve to

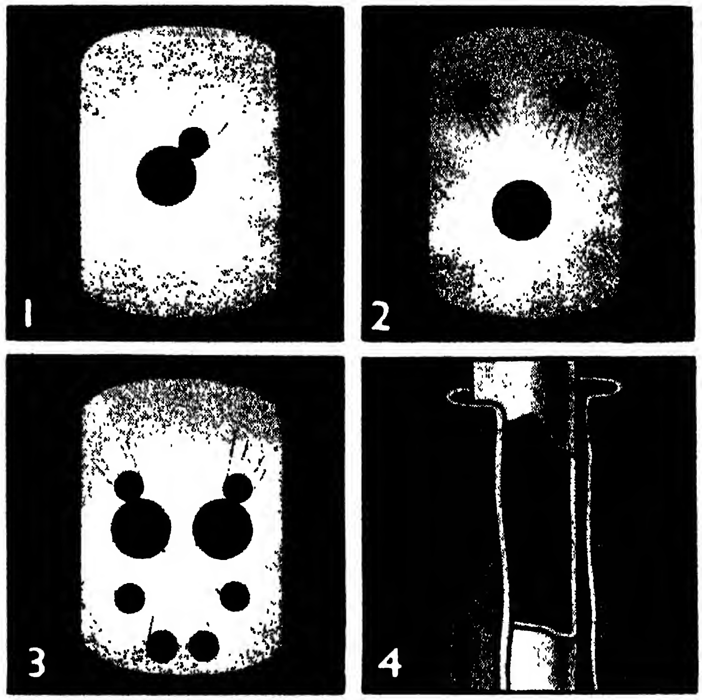
AND HOW IT IS ABLE TO STOP A TRAIN



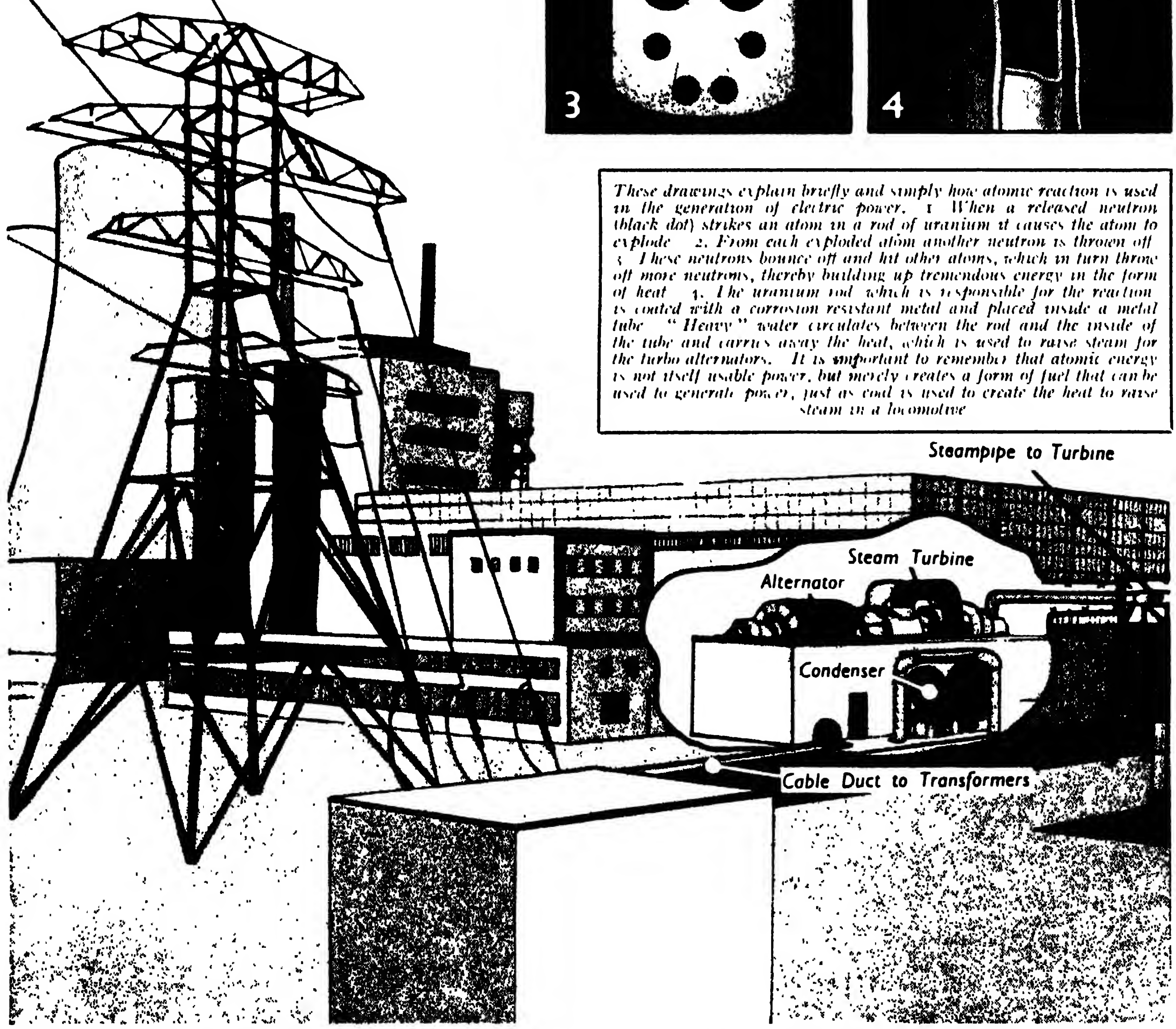
move and permit some of the compressed air stored in the auxiliary reservoir to pass to the brake cylinder The pistons of the brake cylinder are thereupon forced downward applying the brake blocks to the wheels and stopping the train In order to allow the train to start again the brake is released by restoring the air pressure in the brake pipe from the main reservoir This at once causes the triple valve to close the communication between the auxiliary reservoir and brake cylinder and open a way from the brake cylinder to the outside atmosphere The compressed air then escapes from the brake cylinder The spring in the cylinder can now push up the piston and as this happens the brake blocks are withdrawn from the wheels The brakes are, in the ordinary way applied by the engine-driver In case of emergency however the guard can put on the brakes Should a hose coupling become disconnected compressed air escapes from the brake pipe and the brakes at once stop the train The main reservoir of compressed air is on the locomotive but there is an auxiliary reservoir under each carriage as well as under the locomotive for working the brakes of each vehicle In the Westinghouse brake the train or brake pipe is filled with compressed air while the train is running, but in the Vacuum brake used on some railways the train pipe has no air inside but contains a vacuum

HOW THE WORLD'S FIRST NUCLEAR POWER

Current generated at Calder Hall atomic power station goes into the Central Electricity Authority's national grid system at Whitehaven, whence it is dispersed over the north-west area of England to towns as distant as Lancaster and Barrow. Calder Hall cost £15,000,000 to build and was the prototype of a dozen nuclear power stations due to be completed by 1970



These drawings explain briefly and simply how atomic reaction is used in the generation of electric power. 1 When a released neutron (black dot) strikes an atom in a rod of uranium it causes the atom to explode 2. From each exploded atom another neutron is thrown off 3 These neutrons bounce off and hit other atoms, which in turn throw off more neutrons, thereby building up tremendous energy in the form of heat 4. The uranium rod which is responsible for the reaction is coated with a corrosion resistant metal and placed inside a metal tube "Heavy" water circulates between the rod and the inside of the tube and carries away the heat, which is used to raise steam for the turbo alternators. It is important to remember that atomic energy is not itself usable power, but merely creates a form of fuel that can be used to generate power, just as coal is used to create the heat to raise steam in a locomotive

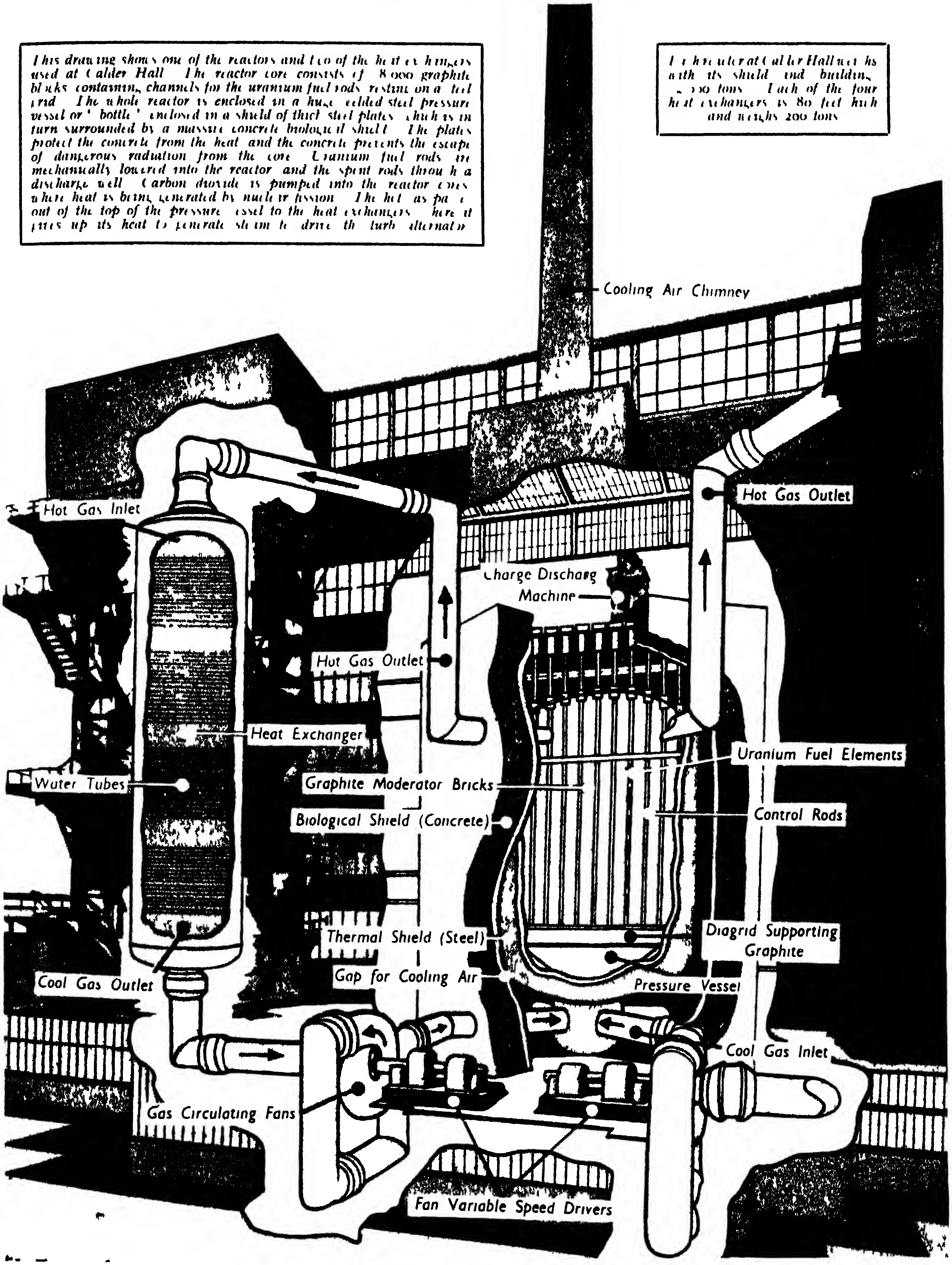


The drawing across these two pages was prepared from material supplied by the United Kingdom Atomic Energy Authority, and shows you what it is like inside Calder Hall, Cumberland. Calder Hall, first full-scale atomic power station in the world, was opened by Queen Elizabeth II on October 17, 1956. The station is primarily intended for the production of the military explosive plutonium; but as a

STATION SPLITS ATOMS TO GENERATE ELECTRICITY

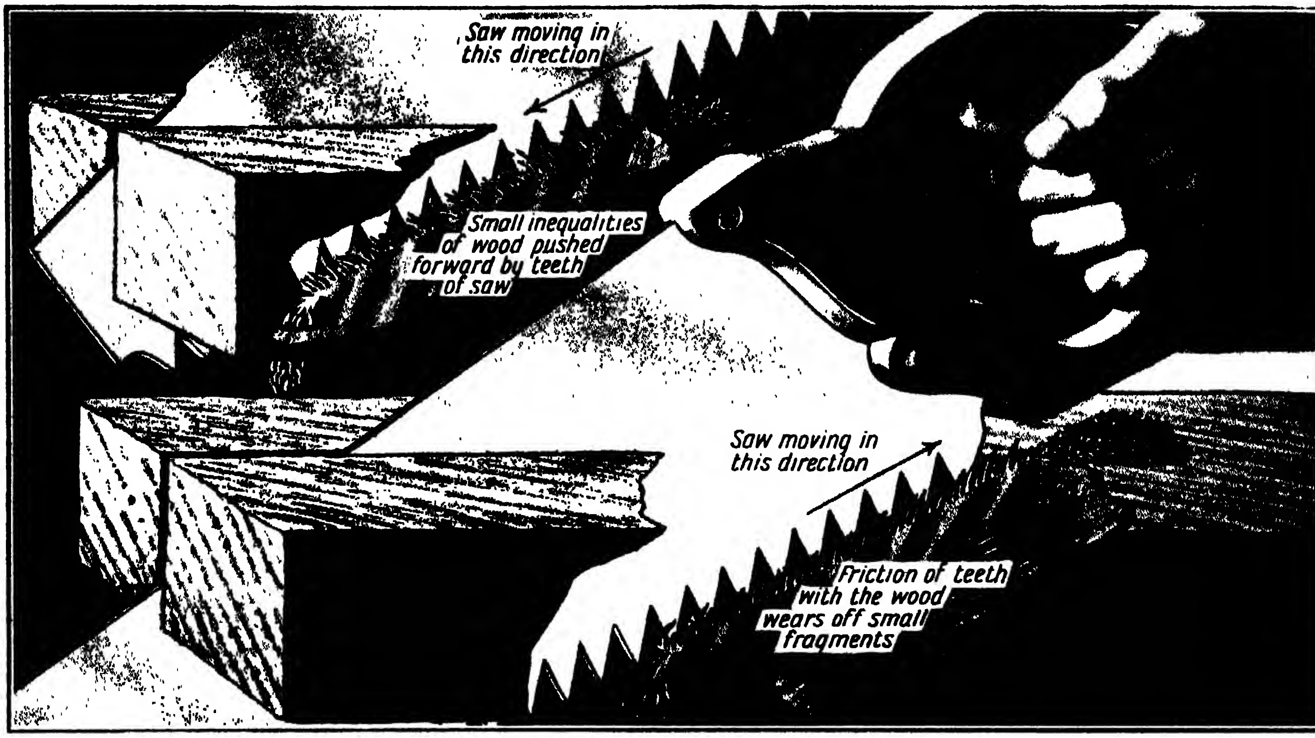
This drawing shows one of the reactors and two of the heat exchangers used at Calder Hall. The reactor core consists of 8,000 graphite blocks containing channels for the uranium fuel rods resting on a steel grid. The whole reactor is enclosed in a huge welded steel pressure vessel or 'bottle' enclosed in a shield of thick steel plates which is in turn surrounded by a massive concrete biological shield. The plates protect the concrete from the heat and the concrete prevents the escape of dangerous radiation from the core. Uranium fuel rods are mechanically lowered into the reactor and the spent rods through a discharge well. Carbon dioxide is pumped into the reactor cores where heat is being generated by nuclear fission. The hot gas passes out of the top of the pressure vessel to the heat exchangers where it gives up its heat to generate steam to drive the turbo alternator

Each reactor at Calder Hall weighs with its shield and building [illegible] tons. Each of the four heat exchangers is 80 feet high and weighs 200 tons



by-product generates electric power for domestic purposes. The structures on the left shaped like egg-cups are cooling towers each 290 feet high. The two chimneys (only one is shown in the drawing) which carry off waste gases that have been made harmless, are each 415 feet high. Photographs in page 332 show technicians at work in Calder Hall, and the story of the atom is told in pages 1125-1127

HOW A SAW CUTS A BEAM IN TWO



We all know that a saw has teeth and that when it is worked to and fro on a piece of wood it will divide the wood. This picture diagram explains how this happens. The pointed teeth of the saw as they are pushed forward raises, as it were, fragments of the wood. Then when the saw, having gone its full length, is drawn back in the opposite direction, it drags with it the small tongues of wood it has raised and wears them off the beam by friction. The saw is indeed a tool in which friction is made use of to work for man. Part of the wood of the beams in the picture is cut away to show the saw and the work of the teeth

In this photograph, which shows a gang of timber hauliers at work, the trunk of a felled tree is being sawn up for transport. The saw used is a double-handled one. The teeth of saws vary a great deal in shape, size and angle, according to the purpose for which the saw is to be used. The teeth are made by cutting, filing, or punching ; but in very large saws, particularly big circular saws, the teeth are made separately and fastened to the body of the saw. Individual teeth can then be removed as they are worn out. A great advance in connection with sawing was the invention of the circular and band saws, worked by machinery at high speed

ROMANCE of BRITISH HISTORY

A BUTCHER'S SON'S DRAMATIC RISE & FALL

The rise and fall of Thomas Wolsey, the butcher's son, is one of the most dramatic stories in English history. He has been described as "probably the greatest political genius whom England has ever produced," and it was his statesmanship that made England a first-class power. He served his master, King Henry the Eighth, well and faithfully, and his ruin by that monarch is a record of base ingratitude. Here is the story

When just before he had reached his eighteenth birthday Henry the Eighth succeeded his father on the throne of England, everyone felt that at last the nation had a king whom it could delight to honour.

The new monarch was over six feet high, fair haired and blue eyed, and was not only a master of tourney and a skilled archer, but also a scholar and an accomplished performer on the lute, organ and virginals. He spoke and wrote proficiently four languages besides his own, and his graceful dancing gave joy to all beholders.

We may wonder why a young prince should have been such a scholar. The explanation lies in the fact that he had an elder brother Arthur, who was expected to become king of England, and his father had therefore designed him for the highest office in the Church in England, namely the Archbishopric of Canterbury.

Henry prided himself on his knowledge of mathematics and theology, and when later on he wrote a book against the teaching of Luther, the Pope was so pleased that he gave Henry the title of Defender of the Faith, a title which the British monarchs have borne ever since, and which appears on all our coins from the farthing to the sovereign.

It was a beginning of high promise, and Henry started well. He took a keen interest in his navy, and began that mastery of the sea which England held with few interruptions for over three centuries.

But it was not long before he gave himself up entirely to pleasure, which soon degenerated into vice, and the handsome young prince developed into a coarse and bloated glutton who kept faith with none, and who became one of the most treacherous and bloodthirsty villains that has ever occupied a throne. Other kings had beheaded their enemies, but Henry cut off the heads of his wives, of his faithful friends, and of his most devoted servants. The men who made him great and rich, together with those who ministered to his pleasures, were all slain one after another, not for any wrong they did, but because the King had become tired of them or resented even the slightest opposition to his evil will.

On one occasion his last wife, Katherine Parr, who was a most devoted nurse, happened to differ from Henry on a theological point. He at once ordered her arrest, and there was every chance that she would have suffered the same fate as two earlier queens. She only escaped by explaining that she had spoken "to minister talk," that is, to make conversation, and owned that it would be unbecoming in her to assert opinions contrary to those of her lord.

"Is that so, sweetheart?" said Henry. "Then we are perfect friends!" And when, in obedience to the order that had been given, the Chancellor arrived to arrest the Queen, he was cursed by Henry as "a knave, beast and fool."

It is one of the shames of history that this cruel and faithless man should have come down to us with the jolly title of "Bluff King Hal." Bluff, according to the dictionary, means frank and hearty, but Henry was neither frank nor hearty. He was coarse and vulgar; he would kiss a person one minute and kill him the next, and all the time he prated religion and out-Pecksniffed Mr Pecksniff in canting hypocrisy. Yet his name and word were respected throughout the length and breadth of Europe, and he was the first King of England to whom the title Majesty was given. All this dignity he owed not to himself but to his great Minister, Thomas Wolsey, one of the greatest statesmen that England has ever had.

The story of Wolsey is one of the romances of historical biography. The son of an Ipswich butcher, he rose through study and industry, and sheer ability, to be chief Minister of the Crown, Archbishop of York, Cardinal of the Church, and almost reached the Papal throne itself. Bishop Mandell Creighton declares that "he was probably the

Henry the Eighth and Cardinal Wolsey discussing affairs of state. From the painting by Sir John Gilbert in the Guildhall of the City of London

Cardinal Wolsey going in procession to Westminster Hall at the height of his fame when everyone was anxious to beg a favour of him
From the painting by Sir John Gilbert in the London Guildhall

greatest political genius whom England has ever produced for at a great crisis of European history he impressed England with a sense of her own importance and secured for her a leading position in European affairs which since his day has seemed her natural right

Dr Creighton explains that when Wolsey came to power England was an upstart trying to claim for herself a decent position in the society of European states. It was Wolsey's cleverness that set her in a place far above that which she had any right to expect

Inspiring National Independence

Wolsey inspired England with the proud feeling of independence which nerved her to brave the public opinion of Europe. He impressed Europe with such a sense of England's greatness that she was allowed to go her own way menaced but unassailed. The spirit which animated the England of the sixteenth century was due in no small degree to the splendour of Wolsey's successes and to the way in which he stamped upon men's imagination a belief in England's greatness

If adds Dr Creighton it is the characteristic of a patriot to believe that nothing is beyond the power of his country to achieve then Wolsey was the most devoted patriot whom England ever produced

His rise was dazzling like that of a meteor and his fall was just as sudden Why did such a great man having reached transcendent heights descend so rapidly with scarcely a friend to speak a word of comfort much less to defend him? The explanation given by historians is that he was ambitious and that vaunting ambition overreached itself Of course he was ambitious both for himself and his country or neither he nor it would have advanced as they did Caesar also was charged with ambition and in both cases the jealousy and envy of lesser men who had neither the ability nor the industry to do what these giants did conspired to ruin them

Wolsey loved display it was part of his policy in order to manifest the greatness of his country and to impress the rulers of Europe but the great state in which he lived and moved angered the nobles and courtiers and their feelings are well summed up in the tongue twisting couplet

Begot by butchers but by bishops bred
How high His Honour holds his haughty head

Thomas Wolsey must have been a very remarkable boy He was not more than eleven when he left school to go to Magdalen College Oxford and at fifteen he was a B A Even in those days this was regarded as remarkable for he came to be known as the Boy Bachelor

He became the personal friend of scholars like Thomas More and the great Erasmus and he was made a Fellow and the Bursar of his college Even as a very young don he gave evidence of his determination to get things done for when the great tower of Magdalen College needed completing and there was some difficulty about getting sanction for the work Wolsey decided to have no nonsense about the matter but started the work himself using the college funds for the purpose As he had not consulted his fellow dons they compelled him to resign

Next he became a rector at Limington in Somerset but here again he got into trouble for some reason, and Sir Amyas Paulet a local magnate put him in the stocks It was an indignity which Wolsey never forgot and years afterwards when he became a great man Sir Amyas was made to suffer for his high handed proceeding though not very severely He was confined for a time to his own house in London

An Undertaker of Delicate Missions

Wolsey's rise in the Church was now rapid He became one of the Archbishop of Canterbury's chaplains and then chaplain to King Henry the Seventh and his energy and efficiency soon attracted that monarch's attention He was sent on a mission to the King of Scotland and then Henry, wanting to send a confidential mission to the Emperor Maximilian whose daughter Margaret he proposed to marry determined to send Wolsey He conversed with him on the subject and was thoroughly satisfied that here was a man with the necessary qualifications for so delicate a mission

Cavendish Wolsey's friend and biographer, tells us that having received his instructions from the King Wolsey

took his leave of the King at Richmond about four o'clock in the afternoon, where he launched forth in a

Gravesend barge with a prosperous wind and tide, and he arrived at Gravesend in little more than three hours, where he tarried no longer than the post-horses were provided ; and he travelled so speedily that he came to Dover the next morning where the passengers were under sail to pass to Calais ; so that long before noon he arrived there, and having post-horses prepared departed from thence without tarrying, making such hasty speed that he was that night with the Emperor."

A Sixteenth Century Hustler

Maximilian was in Flanders, and Wolsey soon transacted his business and started off again for home. He "took post-horses that night," says Cavendish, "and rode without intermission to Calais and arrived at Dover between ten and eleven in the forenoon, and came to the Court at Richmond that night. Taking his repose until morning, he presented himself unto his Majesty on his first coming out of his bedchamber to his closet to Mass, whom when he saw he checked for that he was not on his journey 'Sir!' quoth he, 'If it may please your Highness, I have already been with the Emperor and dispatched your affairs, I trust to your Grace's contentation' ; and thereupon he presented the King with his letter of greetings from the Emperor."

Never was there such a journey made before in such a time. It reads like twentieth century hustling, and Henry was not indifferent to such energy and efficiency. Wolsey was made Dean of Lincoln, one of the best paid ecclesiastical offices in the country, apart from the bishoprics

Soon after this Henry the Seventh died, and his son mounted the throne. The new king found Wolsey a useful man, for while Henry liked to appear in the limelight and get the credit for doing dazzling things, he disliked the plodding and hard work, and so left these things to the brilliant and industrious butcher's son. Wolsey was made Royal Almoner, and given a number of other Church livings, including that of St Bride's in Fleet Street, London, where he had a very pleasant house and garden. Then he was made a member of the Privy Council, a Canon of Windsor, a Doctor of Divinity, and Registrar of the Order of the Garter.

He was still only forty, but his rapid rise was already causing envy, and many enemies now began to watch his steps and wait for a chance to trip him up.

A Great Lover of Display

He loved ostentation, and kept such state as astonished not only his own countrymen, but the ambassadors of foreign rulers. His palace was decorated with rich hangings and huge vases of gold and silver. He was attended by gentlemen in velvet coats and chains of gold When he left his chamber two great crosses of silver were borne before him and gentlemen walked before him bare-headed crying out, "Masters, before, and make room for my lord." Even his cook wore a gold chain round his neck like a mayor

His household included 800 persons, among whom were nine or ten lords, and each of these had two or three men to wait upon him. To support his enormous expenditure Wolsey was given additional revenues, the Bishopric of Durham, the Abbey of St. Albans, and the incomes from the Bishoprics of Bath and Worcester and Hereford. The Pope made him a cardinal, and as he moved about the Cardinal's scarlet hat was borne before him by some lord or gentleman Then he became Chancellor, and before him was borne, with his Cardinal's hat, the Great Seal of England.

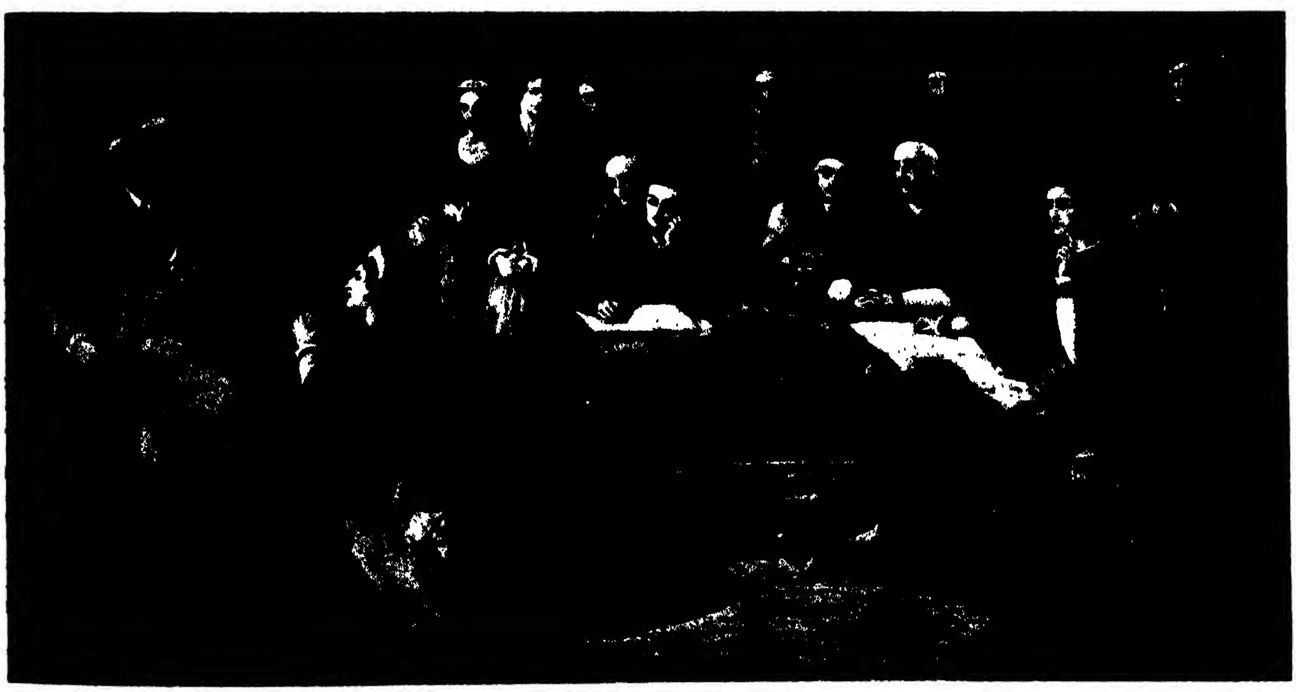
Amazing Ambitions

Wolsey's great idea was that England should hold the balance of power in Europe, and thus actually become the greatest state in the world His ambitious ideas were, for daring and brilliance, almost like those of Napoleon Bonaparte He wanted to make his king Holy Roman Emperor and himself Pope, then together he and Henry would dominate the world.

But his schemes did not all mature. Charles, King of Spain, was elected Emperor, and when the Pope died, although Wolsey was put forward and received seven votes, another was chosen to fill the Papal throne.

If Henry had been content to keep his pleasures and his business apart and leave the latter to Wolsey, all might have been well, but unfortunately the pleasures and the policy became so mixed up together that the policy of the country came to depend entirely on Henry's personal likes and dislikes, his pleasures and his vices.

He wanted to get rid of his wife Katherine of Aragon, who had been his brother's widow. He had lived with her for twenty years and then pretended that he had conscientious doubts as to whether he ought ever to have married



The hearing of Henry the Eighth's petition for the dissolution of his marriage with Katherine of Aragon. The Queen is seen kneeling before the King, and Cardinal Wolsey is seated on the right

From the painting by H. O'Neill, reproduced by permission of the Museum and Art Gallery Committee of the Corporation of Birmingham

her. He made up his mind to obtain a divorce and was determined that if the Pope would not grant this he would break away from the Pope and obtain the divorce in some other way.

Katherine was a Spanish princess, and such a scheme as Henry proposed upset all the clever plans that Wolsey had laid. It offended the Emperor Charles the Fifth, who was Katherine's nephew, and so Wolsey could not throw himself wholeheartedly into the King's scheme. Henry, however, was determined upon the divorce, and when he found that Wolsey was unable or unwilling to persuade the Pope to grant it, he turned upon the Cardinal who had served him so well and determined to ruin him.

A Rapid Fall

Wolsey had been made the Pope's legate or ambassador in England, and Henry had welcomed him as such when he thought that it would be to his advantage, but now he pretended that Wolsey in becoming legate had committed a great crime, and it is true that technically he had broken the law of England, but he had done it with Henry's consent and approval.

Wolsey's fall now became very rapid. Many who were secretly his enemies came out to assist in the downfall. The nobles had always been jealous of a butcher's son rising to such heights of power and privilege, and the lesser people hated Wolsey because he had been the means of extracting from them large sums in taxes for the King's spendthrift pleasures. Almost everyone was against the Cardinal, and his chief enemy was Anne Boleyn, who was to be the new queen as soon as Henry could obtain his divorce.

Wolsey was told to surrender the Great Seal and to retire to his palace at Esher. He remained there through the winter, deserted by nearly all those who had lived upon his bounty, and indeed he had scarcely enough to provide for the wants of his household.

But even then amid his troubles he was thoughtful of others, and his chief concern was for two colleges that he had founded, one at Ipswich and the other at Oxford. Henry dissolved the Ipswich college, but allowed the Oxford one, now Christ Church, to continue, trying to gain for himself some of the honour of founding it.

Wolsey had given the King nearly everything he possessed, including his palace at Hampton Court. Henry, ever faithless, was not even consistent in his enmity and ingratitude. When he heard that Wolsey was ill, he sent him his own physician and hypocritically said that he would not lose his old servant for £20,000. Wolsey snatched at this like a drowning man at a straw, and in gratitude sent the King the only thing he had to give, his fool or jester, Patch, although poor Patch himself was very reluctant to leave his master.

Cardinal Wolsey's arrival at Leicester Abbey after his fall. From the water colour by Sir John Gilbert in the Victoria and Albert Museum

Some time before this, Wolsey had been made Archbishop of York, and he now went north in order to be enthroned in York Minster as had been previously arranged. His money had all gone, and his creditors were worrying him.

He arrived in York, but the day before the enthronement the Earl of Northumberland came to arrest him on a false charge that he had urged the Pope to excommunicate Henry. It was a ridiculous and obviously untrue accusation, but on it a charge of high treason was founded.

A Broken Statesman

Wolsey, although very ill, was ordered to start for London at once. His remaining money was taken, and on the way he was met by the Lieutenant of the Tower, who became his gaoler. The broken statesman became worse. As he travelled sitting on a mule he could hardly keep his seat, and when he arrived late one night at Leicester Abbey he was so weak that it was evident he could not last much longer. The Abbot received him, and he said feebly and pathetically, "Father Abbot, I am come to lay my bones among you."

In his terrible suffering the Cardinal realised the vanity of human pomp and power. Speaking of the King he said:

"He is a prince of a most royal carriage and hath a princely heart, and rather than he will miss or want any part of his will he will endanger the one half of his kingdom. I do assure you I have often knelt before him sometimes three hours together to persuade him from his will and appetite, and could not prevail. If I had but served God as diligently as I have served the King he would not have given me over in my grey hairs."

A Sad Farewell

Shakespeare tells the story of the Cardinal's tragic fall in an imaginary speech which he puts into his lips:

Farewell! a long farewell to all my greatness!
This is the state of man: to-day he puts forth
The tender leaves of hope; to-morrow blossoms,
And bears his blushing honours thick upon him;
The third day comes a frost, a killing frost,
And, when he thinks, good easy man, full surely
His greatness is a-ripening, nips his root,
And then he falls, as I do. I have ventured,
Like little wanton boys that swim on bladders,
This many summers in a sea of glory,
But far beyond my depth: my high-blown pride
At length broke under me and now has left me,
Weary and old with service, to the mercy
Of a rude stream, that must for ever hide me.
Vain pomp and glory of this world, I hate ye:
I feel my heart new opened. O! how wretched
Is that poor man that hangs on princes' favours!
There is, betwixt that smile we would aspire to,
That sweet aspect of princes, and their ruin,
More pangs and fears than wars or women have,
And when he falls, he falls like Lucifer,
Never to hope again.

Wolsey never used these actual words, but he might have done so. They are a sad and vivid epitome of his end.

He died the morning after he arrived at Leicester Abbey, and was buried quietly in the Lady Chapel there. There is little doubt but that Henry would have cut off his head if he had had the chance, but fortunately the great Statesman died before this could happen.

Successive Chancellors, Sir Thomas More and Thomas Cromwell, Henry treated in the same way, and it is an undoubted truth that at his Court and in his service, no one was safe.

WONDERS OF THE SKY

THE PLANET MOST LIKE THE EARTH

The planet Venus is the Morning Star and also the Evening Star, which shine so brightly in the sky at certain seasons. Of course, Venus is not really a "star" but a planet, or member of the Sun's family of worlds, and it circles round the Sun just as our Earth does. It is an interesting planet, for it is in many ways not unlike our own Earth. In these pages are set forth many facts about the sister planet.

THE best known of all the planets is undoubtedly Venus; that is, the best known by sight. Of course, there are other planets which are better known from pictures or descriptions. Saturn, for example, is known to everyone from photographs and drawings because of the rings that encircle its globe, and Mars is well known to the man in the street as a name because of the constant reference to its supposed canals and the speculation about life on its surface. If anything else had made Mars known, a novel dealing with the supposed Martians and their ways would have done so.

But it is one thing to know about a planet and another thing to know the planet itself so as to recognise it. It is in this kind of knowledge that Venus stands pre-eminent among the Sun's family of worlds.

It is the brightest and most beautiful of all the planets, and is the most conspicuous of all, being known popularly as the Morning Star and the Evening Star, according to the time when it is visible in the heavens. So bright is it that it can be seen easily by the naked eye in the daytime when it is nearest to the Earth.

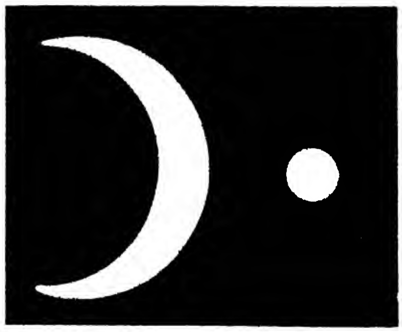
The Ancient Greeks had two names for it. When it appeared as the Morning Star they called it Phosphorus, and when it was seen as the Evening Star it was given the name of Hesperus.

Of course, we must always bear in mind that it is not a star at all, but a planet; that is, it is not a ball of fire, but a body that shines with reflected light from the Sun.

Earth's Twin Sister

In size, density and physical condition it is like a twin sister of the Earth, being more like the Earth than any of the other planets. While the Earth has a polar diameter of 7 900 miles, the diameter of Venus is about 7 600 miles, and its mass or weight is about four-fifths of that of the Earth.

It travels round the Sun in an orbit which is almost a circle, far more circular than the orbit of any other planet. Its orbit lies within that of the Earth, the only other inside planet being Mercury, which is still nearer to the Sun.



This diagram shows the size of Venus when it appears as a crescent compared with its size when it appears as a disc. Of course, the crescent Venus is millions of miles nearer to the Earth than the planet when it shows a full disc.

The most interesting result of this fact that the orbit of Venus lies within that of the Earth is that the sister planet, as seen from the Earth, has phases like those of the Moon; that is, sometimes it appears as a round bright disc, at other times as a crescent, and at other times with forms between these two extremes. The picture diagram on page 503 will make clear why this should be so.

Another interesting result that comes from the fact of Venus's orbit being inside that of the Earth is that the sister planet varies a great deal in size as seen from the Earth. How remarkably great this difference is can be seen from the picture on this page.

Of course, it is not surprising that the size of Venus in the sky should vary considerably, for though when at her nearest she is only 25 700 000 miles away from us, when she is at her farthest, on the other side of the Sun, she is 160 100 000 miles from the Earth, or more than six times her nearest distance.

What is the nature of this planet so near the Earth in size? Well, we know very little about Venus herself, for she is surrounded by an atmosphere of considerable density, certainly as dense as that which surrounds our Earth.

There are several ways in which this fact is known. In the first place, the brilliance of the planet in the sky decreases from the centre toward the limb or edge, and this would follow naturally from the possession of an atmosphere, for the atmosphere would absorb more of the Sun's light where it was thicker; and, of course, as seen from the Earth, the atmosphere is not so deep at the centre of the disc as at the edges, where we are looking through more of it.

Venus being nearer to the Sun than our Earth, the Sun would appear larger in the sky to a person on the sister planet. These two pictures show the relative sizes of the Sun as seen from the Earth and from Venus. The Earth view is shown in the left-hand picture and the Venus view on the right.

Twilight Effects

Another reason for believing that Venus has an envelope of atmosphere is that when we see it in one of its phases other than a complete disc, and there is a terminator or dividing line between the illuminated and unilluminated parts, we have twilight effects such as are to be seen on the Earth.

Finally, when the crescent phase of Venus is very thin, we see illumination

beyond the horns or points of the crescent, and this can only be caused by an atmosphere round the planet.

The markings seen on Venus by means of a telescope are very faint indeed, but by studying them the eighteenth century astronomers concluded that the planet rotated on its axis in 23 hours 21 minutes, that is, in a period rather less than the 24 hours of the Earth's rotation. This was accepted right down to about 1880, when further study by the Italian astronomer Schiaparelli suggested that the period of rotation was not about one of our days, but 225 days. The observations of other astronomers rather confirmed this. To put it in other words, it was suggested that just as our Moon turned round on its axis in the same time as it took to make a journey round the Earth, so Venus rotated on its axis in 225 days, the same period that it took to make one revolution round the Sun.

If this were so, then Venus would always present the same side of its globe to the Sun, just as the Moon always presents the same hemisphere to the Earth. This would mean that one side of Venus enjoyed perpetual day, while the other side had everlasting night.

As a result of the very latest observations, however, astronomers do not now believe this, and it is interesting to know why they have changed their view. It has all come about through the work of a little instrument known as a thermopile, a very delicate apparatus that can record the heat radiated by a distant world or star.

Testing a Planet's Heat

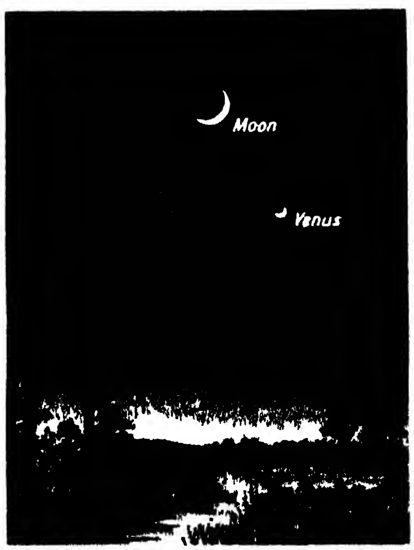
If the dark hemisphere of Venus were really always turned away from the Sun it would receive no heat, and therefore could not radiate any. But when this dark hemisphere is tested with the thermopile the instrument definitely records an appreciable amount of heat. It is therefore concluded with good reason by the astronomers that that part of the sister planet must be turned towards the Sun at intervals so as to receive heat and be able to radiate it. It is now believed that Venus rotates on her axis in a period of about five days. Some astronomers, however, still maintain that the period of rotation is a little under 24 hours.

When we understand that this planet has an atmosphere we naturally want to know what kind of an atmosphere it is. Is it like the atmosphere of the Earth, with oxygen and water vapour in it?

In the old days there would have been no way of discovering this, but by means of that wonderful instrument the spectroscope, which is described and pictured on Pages 450 to 452, we are able to examine the atmosphere of Venus.

Two photographs of the planet Venus taken at the famous Lick Observatory in America. That on the left was taken by means of the violet rays and that on the right with the aid of infra-red rays

The light which we receive from the sister planet is, of course, reflected sunlight, and some of this light has penetrated the atmosphere of Venus to a considerable depth before being reflected to us. As it comes back it passes through layers of the planet's



The planet Venus shows similar phases to those of the Moon, and if it were larger we should often see it with the naked eye as shown here. It is seen in this form through a telescope

atmosphere, and then travelling through our own atmosphere, passes through the slit of the spectroscope.

If there were oxygen and water vapour in that part of Venus's atmosphere through which the light coming to us has passed, then we should see certain lines in the spectrum. But these lines are absent, and that suggests an absence of oxygen and water vapour.

We must not, however, jump to the conclusion that Venus has no oxygen or water, for this may be deeper down in the atmosphere than the light which is reflected to us has penetrated. The Sun's light may be reflected by clouds which are high up in the atmosphere of Venus.

All we can say at present is that we know very little indeed about the nature of the atmospheric envelope which surrounds the planet Venus.

The question is very often asked, can there be living beings on Venus? Any answer must, of course, be a mere matter of speculation. The physical conditions on the surface of Venus are probably more like those of the Earth than can be found on any other planet, and if the atmosphere contains oxygen and water vapour it is quite possible that life may exist on the planet. Professor E. B. Frost, of Yerkes Observatory, says that living beings are much more likely to exist on Venus than on Mars.

It used to be thought that the planet was rotating and revolving round the Sun in an upright position, but it is now believed by some astronomers that the planet is so tilted that its north and south poles come alternately almost directly under the Sun.

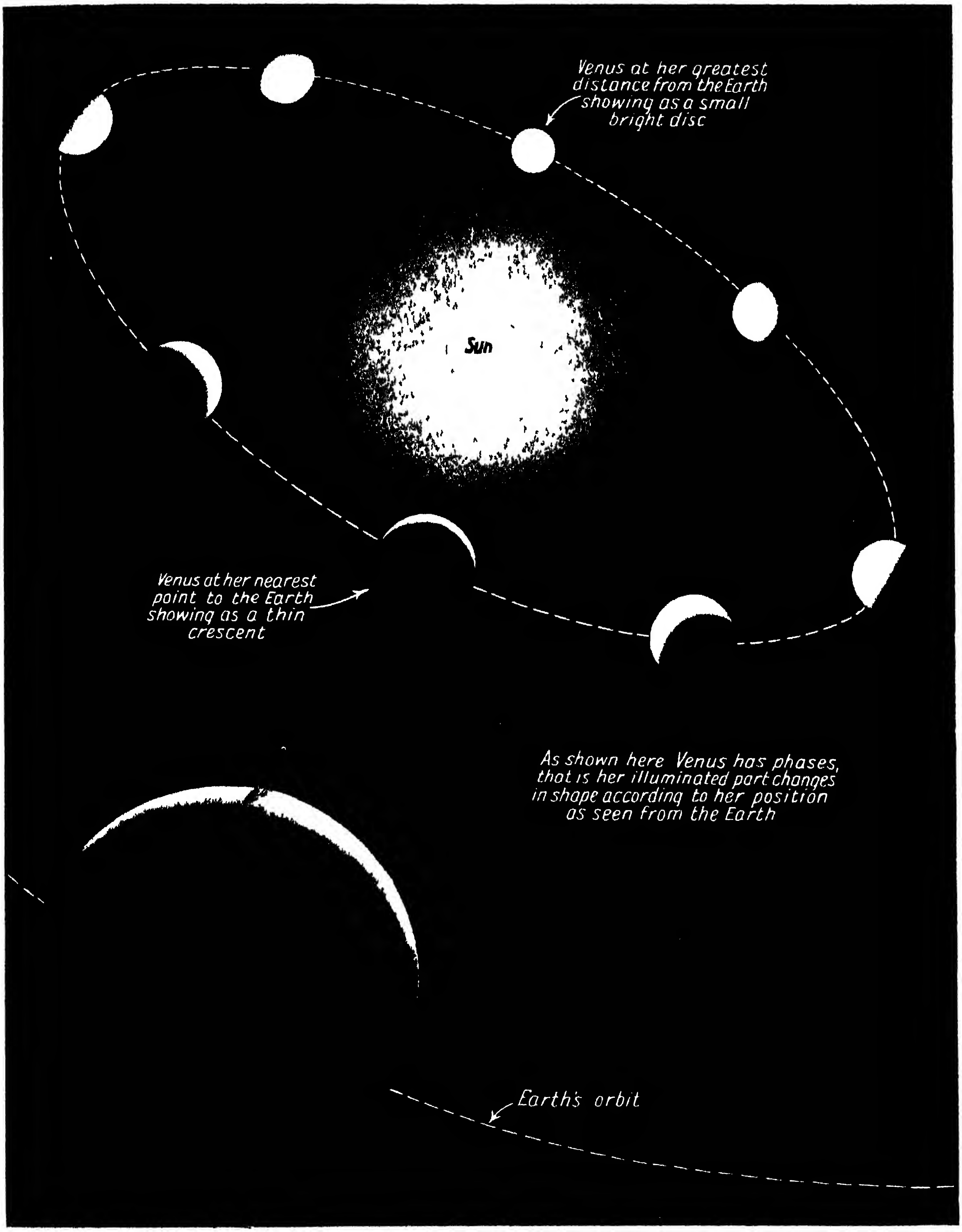
The Ancients knew that Venus had phases, but they believed that she could never show us more than half her illuminated surface. It was Galileo who, in 1610, discovered with his newly invented telescope that the sister planet exhibited a gibbous phase, like our Moon when it is nearly full.

A Strange Announcement

Men of science in his day were very nervous about announcing new discoveries. They often had to be on their guard for fear of persecution. We read on Page 85 how the Dutch astronomer, Christian Huygens, when he discovered the rings of Saturn, did not publish the fact plainly, but in the form of a Latin cryptogram. Similarly Galileo announced his discovery about the gibbous phase of Venus by publishing a Latin anagram. When the letters of the Latin words were rearranged they made a sentence which, translated, reads, "The Mother of the Loves imitates the phases of Cynthia." The Mother of the Loves, of course, means Venus, and Cynthia was a name for the Moon.

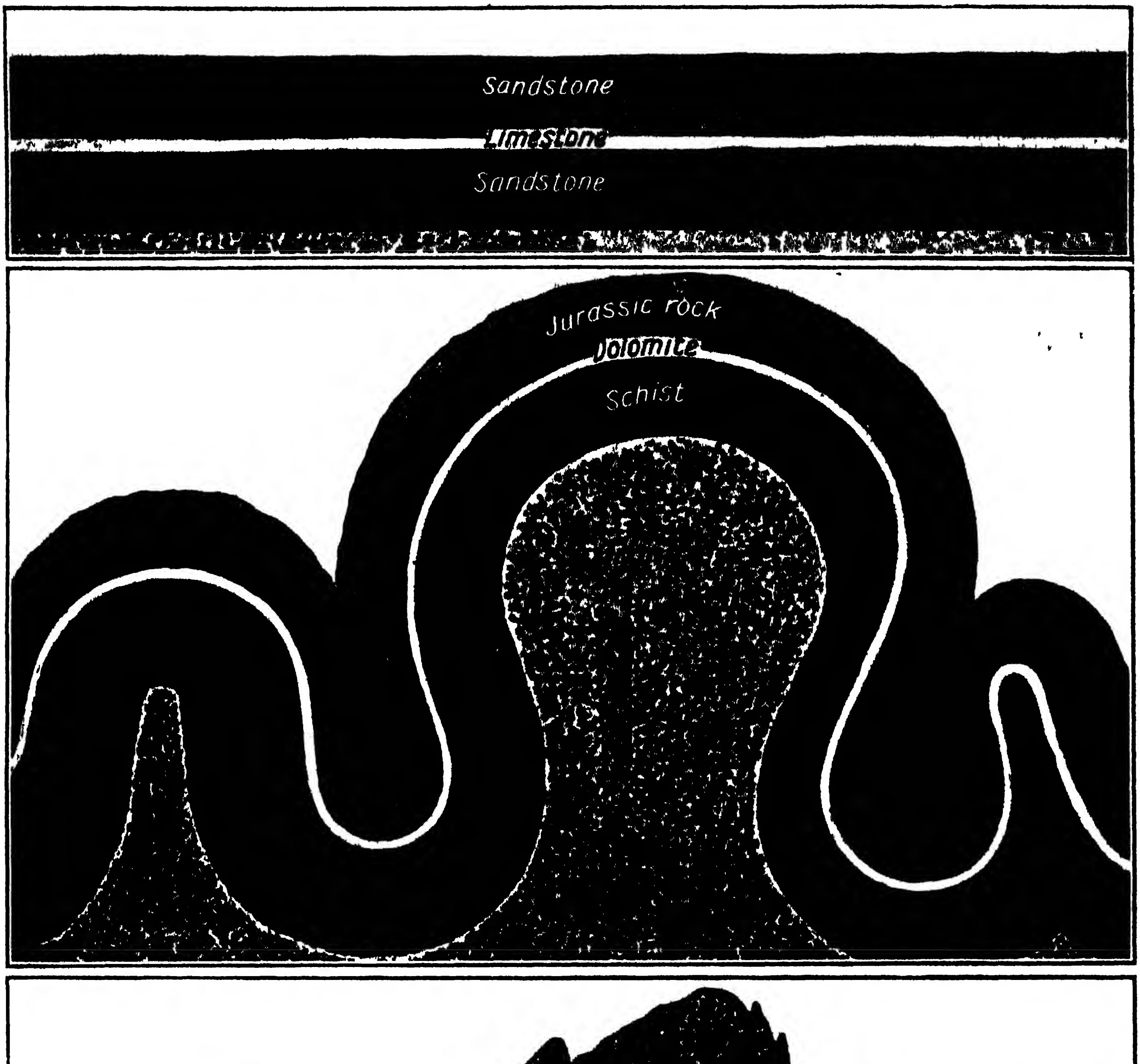
So far as we know, Venus has no satellite or moon.

WHY VENUS DOES NOT ALWAYS APPEAR ROUND



As seen from the Earth the planet Venus does not always appear as a round globe It has phases like the Moon, and is sometimes a crescent, although we need a telescope to see this. This picture diagram explains the reason for the phases. Venus travels in an orbit between the Sun and the Earth, and it is only when we see Venus on the other side of the Sun that she shines as a bright, round disc When she is on the near side of the Earth we see only part of her surface lighted up by the Sun, and so she appears as a crescent or in some other phase Venus is nearly 25 million miles nearer the Sun than is the Earth

THREE STAGES IN THE HISTORY OF THE ALPS



The Alps, which rise from 5,000 to 15,000 feet above sea level, were the terror of the ancient world, but they have now become the playground of Europe How was this great mountain range formed? Well, the pictures on this page show three stages in its history. The Alps are made up of different kinds of rock, and originally these rocks were deposited in successive layers, as shown in the top picture. This means that at one time the Alpine region was under water. Then it was raised up out of the sea, and owing to pressure from the sides the layers of rock were folded and twisted This stage is shown in the second picture. But all the time the wind and weather have been at work wearing away the softer rocks. Even the hard granite has been much eroded and is very uneven in shape, as we can see in the third picture which shows a section through the Mont Blanc range with Mont Blanc itself in the centre

WHAT LATITUDE AND LONGITUDE MEAN

Latitude and longitude are long words, but they describe very important things, and we should certainly understand what they mean. In these pages the parallels of latitude and meridians of longitude, imaginary lines that go round the Earth from north to south and from east to west, are explained in such a way that all can understand their importance

A BOY or girl looking at an atlas might well ask what are those strange lines that cross the map from top to bottom and from left to right. Sometimes they are straight and parallel and sometimes they are curved or slanting. If a geographer were asked the question he would reply that they are parallels of latitude and meridians of longitude. But that would not help us very much. It would give us their correct names, but it would not explain their use or why they are there on the map.

Their real purpose is to help us in knowing exactly where any place is situated on the surface of the Earth. Let us see why they are so important. If we take a plain indiarubber ball and mark an ink spot on it, it would be very difficult to explain to a person who could not see the ball where the spot was, especially if the ball were spinning round or rolling along the ground. Make the experiment and try to explain to your brother or sister on what part of the ball you have made the spot. You would not say it is near the top or the side or the middle, for a ball has no top, side or middle.

Finding Our Way About

Now it is like this with places on the Earth's surface and the parallels of latitude and meridians of longitude are imaginary lines all over the globe which have been numbered so that we can say a place is on or near such a line of longitude and such a line of latitude.

When we come to our Earth we are helped by the fact that it turns round and round regularly on an imaginary line or axis. Now the ends of this axis, which we call the North and South Poles, give us two fixed points from which we can begin to reckon. Midway between them—that is at exactly the same distance from each Pole—men of science imagine a great circle to be drawn right round the Earth, and this circle they call the Equator from a Latin word meaning 'to make equal.' The Equator divides the globe of the Earth into two equal halves or hemispheres, a northern hemisphere and a southern hemisphere. This word means half a sphere.

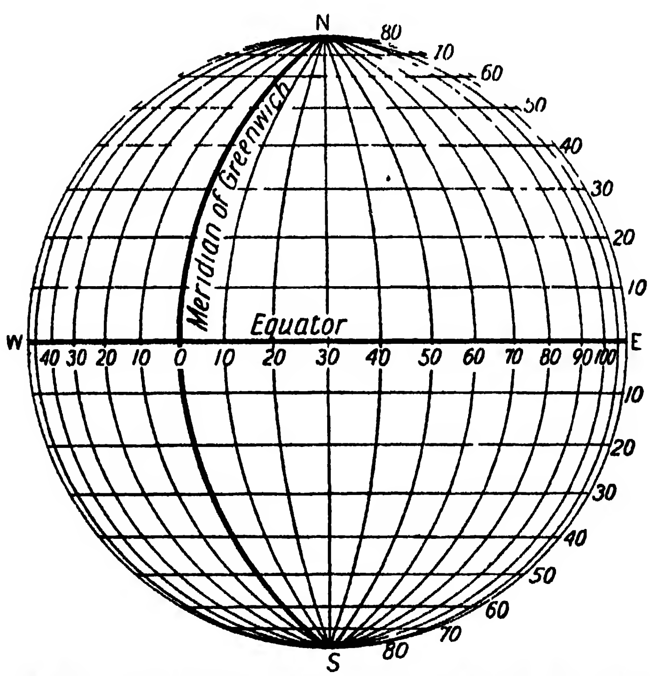
The Importance of the Equator

If we can get hold of a globe of the Earth while we are reading this story it will help us to understand things better. It will be seen at once that with the two poles and the Equator we are able to give some idea as to where a place is on the Earth. We can say that it is north or south of the Equator and we can say that it is nearer the Equator than it is to the North or South Pole, but that does not carry us very far.

To help us men have imagined that a number of other circles are drawn round the Earth north and south of the Equator at regular intervals and parallel to the Equator. Of course, as we can understand and as we can see on a terrestrial globe, these circles get smaller and smaller as they get nearer the Pole. That is why the Equator is called a Great Circle and these others are called Small Circles.

The correct name of each circle is a parallel of latitude. The name parallel is given because the circles are parallel to the Equator and the word latitude, which comes from a Latin word meaning breadth, is used for a very interesting reason.

The ancient peoples knew only a very small part of the Earth and the part they knew was much greater from east to west than it was from north to south. They travelled from Gibraltar as far as North India, but they went only a very short distance north and south of the Mediterranean Sea. Men always use the term 'breadth' for the smaller dimension of any surface and the term 'length' for its greater dimension, and so the ancients called the distance from north to south latitude or breadth while the distance from east to west on the Earth they called longitude, from a Latin word meaning length.



The Earth is divided by the Equator into two equal halves, and smaller circles run round north and south parallel to the Equator. These are called Parallels of Latitude. Circles are also imagined going round the Earth the other way, through the Poles and cutting the Equator at right angles. These are known as Meridians of Longitude. On this flat diagram we see only half of each circle, because we are looking at one side only of the globe. The parallels of latitude are numbered north and south from the Equator, which is 0. Latitude 90, whether north or south, is really only a point at the Pole. The meridians of longitude are numbered east and west of that of Greenwich, which is 0, to its continuation on the other side of the world, which is called meridian 180

What Latitude Is

Latitude, therefore, is the position north or south and we always reckon it in relation to the Equator. The latitude of a place is its distance north or south of the Equator. If a place is situated between the Equator and the North Pole it is in north latitude, and if it is between the Equator and the South Pole it is in south latitude. The places near the Equator are said to be in Low Latitudes and those nearer the Poles are in High Latitudes.

Now how many parallels of latitude are there? Let us imagine a Great Circle going the other way round the Earth—that is, through the Poles and

cutting the Equator at right angles. This circle is divided into 360 parts known as degrees, and the parallels of latitude pass through these divisions, each parallel of course touching the circle twice, first on one side of the Earth, and then on the opposite side. There are thus 180 parallels of latitude, and they are numbered beginning at the Equator from 1 to 90 in the Northern Hemisphere and from 1 to 90 in the Southern Hemisphere.

But latitude alone will not enable us to fix the exact position of a place on the Earth's surface. We may know that a place is situated at 45 degrees north latitude, which means it is about midway between the Equator and the North Pole, but it may be anywhere on that parallel which runs right round the Earth. Something more than latitude is needed if we are to know exactly where a place is.

To help us there are other imaginary lines supposed to be drawn on the Earth's surface, going not round parallel to the Equator, but in the other direction, crossing it at right angles and passing through the North and South Poles. These are called meridians of longitude, "meridian" being a word that means midday. It was given because places on the same meridian and on the same side of the Earth have midday at the same moment. It is easy to decide how the parallels of latitude shall be numbered, because the Equator can be reckoned as a starting place, but from where are we to begin numbering the meridians? We could, of course, start anywhere, and in the old days there was a good deal of confusion because different nations started numbering from different meridians.

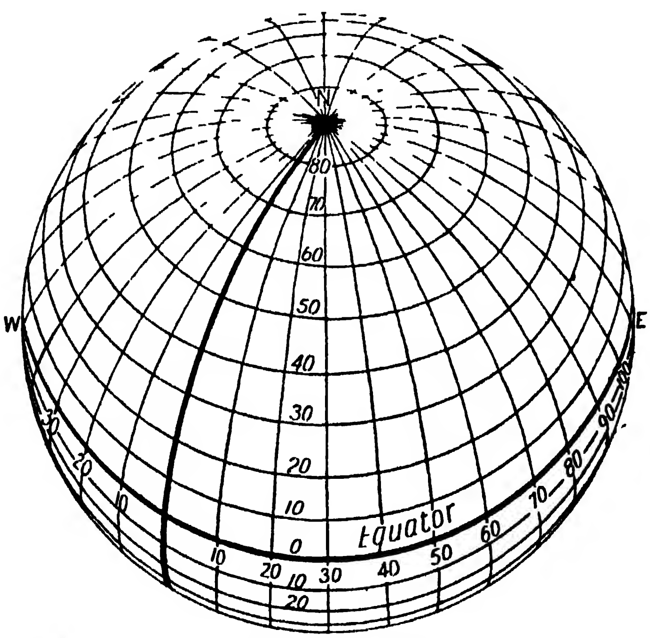
Following English Practice

Now, however, by agreement a large part of the world follows the English practice of beginning with the meridian passing through Greenwich, which is numbered 0. Then the other meridians are numbered from 1 to 180, starting on the east and west sides. We thus speak of a place being on meridian 25 east or 25 west, or, as we shall put it, the longitude is 25 east or 25 west. East longitude means places east of the meridian of Greenwich as far as meridian 180, and west longitude means west of Greenwich as far as this same meridian 180, which is on the opposite side of the globe and is really a continuation round the world of the Greenwich meridian.

The greatest longitude which a place can have is 180 degrees east or 180 degrees west. We put a little ° after the figure to indicate degrees. Thus, with the meridians of longitude and the parallels of latitude as already described, we can very nearly indicate the position of any place on the Earth's surface.

How Greenwich Became Famous

We must, however, be more exact than saying it is near the place where a certain meridian cuts a certain parallel, and we get this accuracy by dividing the degrees of latitude and longitude into smaller portions known as minutes and seconds. Each degree of longitude is divided into 60 minutes and each minute into 60 seconds. The result is that when we know that London is situated in 51 degrees 32 minutes north latitude and 0 degrees 5 minutes west longitude, we are able to find its position with the very greatest exactness on a globe of the Earth.



In this picture we are looking down slantingly on the northern half of the globe of the Earth, and can see how the parallels of latitude run round in circles, getting smaller as they approach the poles. The dark meridian is that which runs through Greenwich and is numbered 0. This diagram and the one on the previous page show only every tenth parallel and meridian

Minutes and seconds are generally represented by little dashes, thus ′ and ″. We might ask why the meridian of Greenwich was chosen as the starting place and numbered 0. Well, this place on the south side of the Thames, five miles from the City of London, had the famous observatory where astronomers studied these matters, and they naturally drew their meridian line through Greenwich and reckoned east and west of where they were working. Some other nations, however, start with a different meridian, the French, for example, calling the meridian of Paris 0.

Where the Longitude is O

It is interesting, when we pass down the Thames on a steamboat, to notice as we are opposite the Royal Observatory at Greenwich, the longitude painted up on the wall 0° 0′. Greenwich was chosen by most nations as the 0 meridian because it was very convenient, there being more English maps and charts with this meridian marked as 0 than there were maps or charts of any other nation. That was due to the fact that England has possessions in so many parts of the world and had done more exploration of the sea than any other nation.

Knowing the latitude and longitude of a place, we can always find it on a map. For example, Bristol is in latitude 51° 28′ north and in longitude 2° 25′ west. We take the map of England and find the meridian of longitude which is numbered 2 on the west of Greenwich. Then nearly half-way between that meridian and the one numbered 3 is the meridian 2° 25′ west of Greenwich. Now we find on this line the place where the parallel of latitude numbered 51 crosses, and 28′ north of that, that is nearly half way to parallel 52, is the spot where Bristol is situated. Generally the meridians marking minutes and seconds are not drawn on maps, but are merely indicated by divisions in the border.

A Splendid System

It is a splendid system, for while many places can have the same latitude and many places the same longitude, no two places can have the same latitude and longitude, for only one place can be on the exact point where a parallel and a meridian cross.

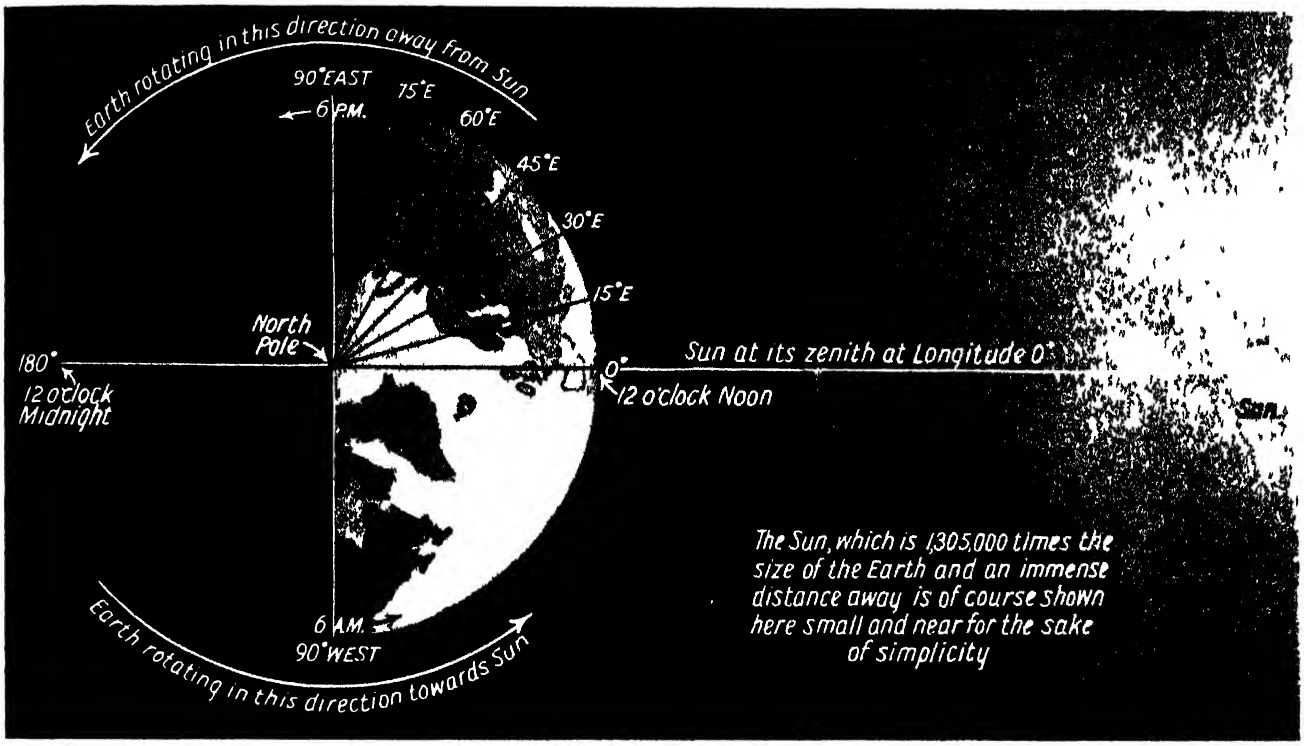
While the greatest longitude a place can have is 180, the greatest latitude it can have is 90°, because the parallels of latitude are numbered north and south from the Equator up to 90.

There are several other points that need to be borne in mind when we are considering latitude and longitude. North and south are definite points fixed by the Poles, but there is no definite and unchangeable east and west point. To a person living in London, Berlin is east, but to a person living in Moscow, Berlin is west. So to a Londoner New York is in the west, but to a San Franciscan New York is in the east.

Another point to be remembered is that the distance between two meridians of longitude is not everywhere the same. We can see this for ourselves by noticing that the distance between two meridians is much greater at the Equator than it is as we travel north or south, for the meridians gradually come together till they actually meet at the Poles. At the Equator a degree of longitude measures 365,185 feet,

and in the English Channel it is only 235,195 feet. In the neighbourhood of the north of Greenland it is 63,610 feet, and at the North Pole it is nothing at all, and is represented by 0.

But even the degrees of latitude are not all exactly the same length. They would be if the Earth were a perfect sphere, but as we know it is slightly flattened at the Poles, and so the degrees of latitude vary a little. At the Equator a degree is 362,644 feet, in the English Channel it is 364,880 feet, and in the extreme north and south, near the Poles, it is 366,180 feet.



This picture diagram, in which we are looking down on the Earth from above, shows how our globe in its rotation moves round into the Sun's light, the passing of time being reckoned by the position of the Sun in the sky, which is here shown directly overhead at the Equator at Longitude 0°. As the Earth moves round time passes, and for every fifteen degrees of longitude there is one hour's difference in time. East of the meridian of Greenwich, time is later than Greenwich Time, and west of that meridian it is earlier. This diagram is drawn from a design by Mr Kenneth A Ray, M.A., a teacher of geography on modern lines

But how are the latitude and longitude of a place determined? Well, as we know, the Earth turns on its axis from west to east once in every twenty-four hours, and as a result we get day and night. Morning dawns as each place comes round to face the Sun, so that it begins to shine above the horizon, and night falls as the Earth, in its continued turning, passes out of the light of the Sun, which appears to sink in the west.

In its apparent passage across the sky the Sun reaches the highest point, which is called its zenith, and this is at midday. Then in twenty-four hours the Sun is once again at its highest point, having been right round a circle which, as we know, is divided into 360 parts called degrees. Twenty-four hours of time, therefore, are equal to 360 degrees of longitude; in other words one hour is equal to 15 degrees.

Considering Greenwich as the prime meridian from which all others are reckoned, we know that if the Sun reaches its zenith at a certain place one hour later than midday at Greenwich the place must be on the fifteenth meridian west of Greenwich, for the Earth is turning round on its axis from west to east and the Sun's apparent journey in the sky is therefore from east to west. In other words its longitude is 15 degrees west.

Ships at sea determine their longitude by means of a chronometer, which is a very accurate clock indicating the time at Greenwich. A ship's officer observes the Sun near noon by means of an instrument called the sextant, and the moment the Sun appears to reach its highest point in the sky he calls out to someone looking at the chronometer with Greenwich time. From the difference of time between Greenwich and the place of observation the longitude of the place is calculated. The chronometer is checked at regular intervals by the wireless time signals sent out from English and other stations and picked up by the ships.

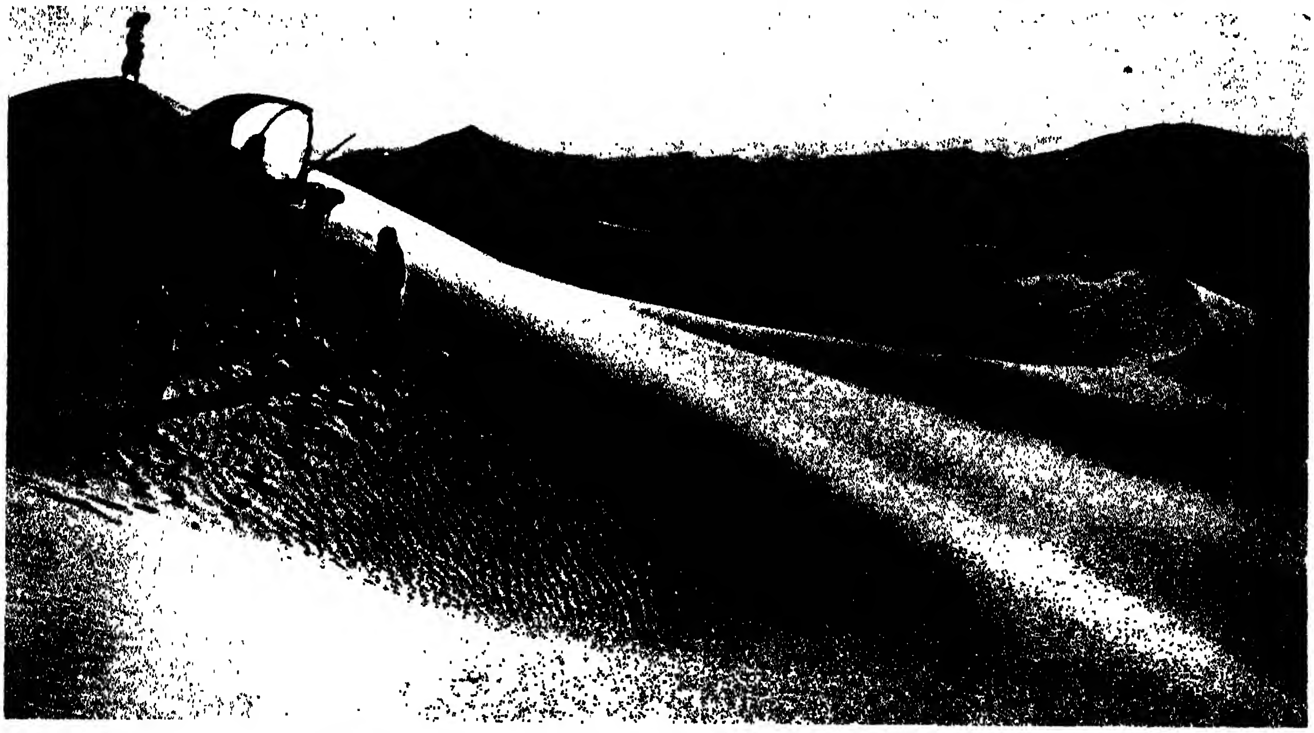
It is interesting to know that if two ships set out at the same time from any port and sail round the Earth, one going eastward, and the other westward and arrive back at the original port together, they will differ by two days in their reckoning.

The captain of the ship going west has to put his clock back continually in order to keep local time as he travels, and eventually on his return he has lost twenty-four hours. The captain of the other ship travelling eastward has also to alter his clock in the same way in order to keep local time, but he must put the hands on as he travels, and when he gets back having sailed completely round the globe, he will be twenty-four hours ahead of time. One will thus have lost twenty-four hours on the time kept at the starting port while the other will have gained the same amount.

Latitude was originally determined by observing the position of the Pole Star. At the Equator this star appears on the horizon, while at the North Pole it is seen overhead. Between the Pole and the Equator it appears at various angles and from its elevation, that is its position in the sky, the latitude of a place was determined. In the southern hemisphere a star in the Southern Cross was used.

Nowadays, however, latitude is more conveniently reckoned by the position of the Sun on the celestial Equator, that is by observing the noonday altitude of the Sun. Ships always carry with them the Nautical Almanac or other publication which records the distance of the Sun from the celestial Equator on every day of the year. When, therefore, the ship's officer finds by observation the noonday altitude of the Sun he can soon find his latitude by reference to the tables.

WAVES OF SAND AND WAVES OF SNOW



We know how the surface of the water is broken up into waves by the action of the wind playing over it, and how these waves travel along. Well, in the same way the wind causes waves in the desert, where there are long stretches of fine sand. The size of the waves depends upon the strength of the wind. Sometimes there are mere ripples less than an inch high and anything from one to seven inches long, while at other times the waves will be two or three feet high and anything up to fifty feet long. Sand dunes are really large waves which move very slowly. In this photograph, taken in the Sahara, we see both large waves and ripples

Dry snow, such as is found in the Arctic and Antarctic, is blown into waves, the size varying according to the intensity of the wind Being lighter than sand, the snow waves move more rapidly than sand waves, and they can actually be seen moving forward. This photograph, taken in the Antarctic, shows waves in the dry snow. Very often smaller ripples can be seen on the surface of the larger waves, although this happens less often in the case of snow than it does with sand

A DISCOVERY LOST FOR MANY YEARS

We may have heard people use the word Mendelism when speaking of the breeding of flowers, birds or animals. The word is made up from the name of an Austrian abbot, called Mendel, and Mendelism is one of the most important discoveries that have ever boen made in connection with animals and plants In these pages it is explained so that all can understand what it means

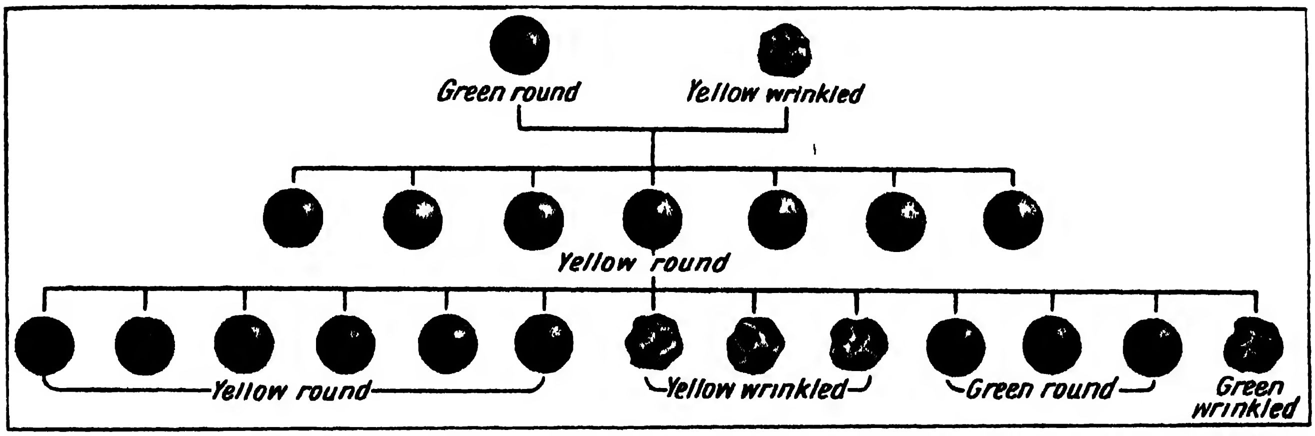
A BOY who thought black guinea-pigs very attractive decided to keep these animals as pets He made up his mind that he would have nothing but pure bred black guinea pigs and so he went to a shop where they sold such animals and bought a pair He asked the tradesman if they were thorough bred and in reply the man said "Of course they are You can see that they are pure black without any white spots"

The guinea pigs were taken home and placed in a hutch But later on, when they had a litter the boy was surprised to find among the young guinea-pigs not only black ones but white as well

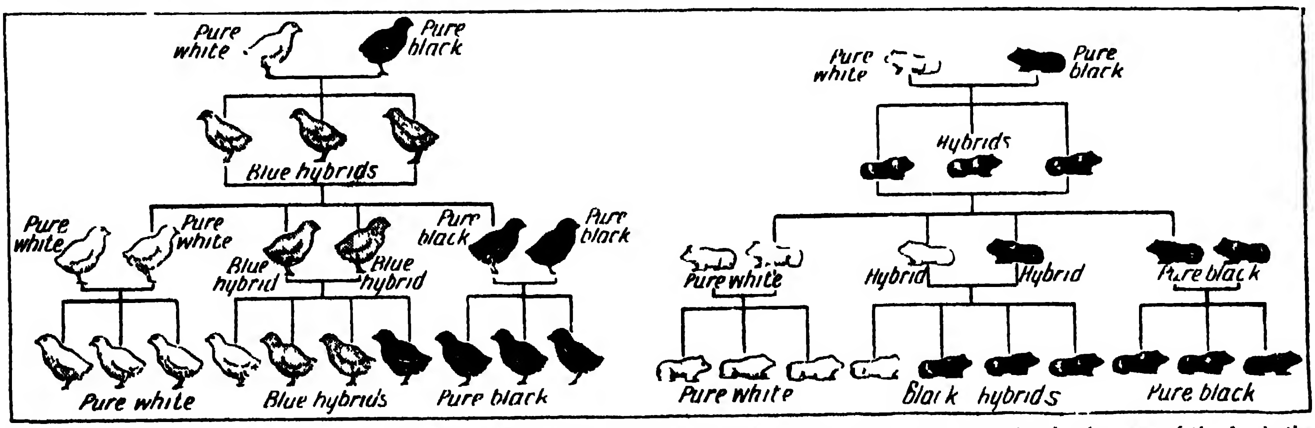
He could not understand this at all How could pure bred black guinea pigs have any white children? He went to the dealer from whom he had bought the pair of black guinea-pigs and that tradesman was quite as puzzled as the boy He had never heard of such a thing as this happening before he said

Now the boy had an uncle who was a student of science and he was able to explain the apparent mystery And very interesting the explanation is

But before we give the explanation of the black and white guinea pigs coming from all black parents we must go farther back in time and describe some experiments which an abbot of Bruun now in Czecho Slovakia but then in



When green round peas are fertilised by pollen from yellow wrinkled peas the offspring are all yellow round peas This is because roundness and the colour yellow are what is known as "dominant," that is, they overcome the qualities of green colour and wrinkled shape, which are therefore called by scientists "recessive" That word simply means "receding" or "withdrawing" When yellow round peas are fertilised by one another they produce yellow round peas, yellow wrinkled, green round and green wrinkled in the proportions shown The yellow wrinkled and green round peas of this generation each produce thorough-breds of their kind



When pure white Andalusian fowls or guinea-pigs are mated with pure black all their children are hybrids In the case of the fowls the hybrids are in colour a mixture of black and white called "blue" This is because neither colour is dominant and so both have an equal share in the offspring. In the guinea-pigs, however, black is dominant and white recessive, so all the hybrids are black and look like thorough-breds When, however, they are mated with hybrids, one half of the offspring are hybrids, one quarter pure black and one quarter pure white. When these pure white or black guinea-pigs, descended from hybrids, are mated with pure white or black, their children are all pure white or black. When a hybrid black is mated with a hybrid white half their offspring are black hybrids, a quarter pure black and a quarter pure white. The same thing happens with the fowls, but as can be seen by the diagram their hybrids are blue and neither black nor white We can never tell whether a black guinea-pig is pure-bred or a hybrid till we see its children

Austria, carried out in the middle of the nineteenth century.

The abbot's name was Gregor Mendel, and he was a student and teacher of science. But what surprised his neighbours was that they used to see him every day in the gardens of the cloister at Brünn, working like an ordinary gardener, and paying a great deal of attention to some garden peas which were growing there.

No animals coming from a common stock have produced such a great variety in form and character as the dogs. They are all believed to be descended from the wolf or jackal, or perhaps both. Yet we get such extraordinary contrasts as are shown by the Greyhound and the Bulldog, the Newfoundland and the Dachshund, the Pekingese and the Fox Terrier. In these pictures we see a remarkable contrast The dog on the left is a Dandie Dinmont and that on the right a Cocker Spaniel

He did not seem to worry much about the flowers, but was exceedingly interested in the shape and colour of the peas when they formed in the pods.

It soon became known that he was not interested in growing peas which would make a fine dish for the table, but that he was studying something which was described as "the laws of inheritance." At one time he had 22 different kinds of peas under cultivation in the garden, and he used to save the pods very carefully, keeping the different peas apart, so that they should not get mixed, and then growing new plants from them in separate plots of ground.

He was particularly interested in seeing the differences between the peas when they formed, that is, whether the pods when opened showed round or wrinkled peas, and whether each of these kinds was yellow or green. He was also interested in the actual shape of the seed-pod itself, whether it was smoothed and inflated or whether it was drawn in between the peas so as to show their shape, more or less, from the outside.

Other points he also considered, such as the colour of the different pods, how the flowers grew, whether scattered along the stem or bunched together at the top, what height the plants reached, and so on.

Mendel was very particular that the pollen of one kind of pea should never reach the stamens of another kind, except when he himself put it there for a purpose. He kept careful notes of the parents of each plant and also of the character of their children, that is, the peas in the pods, and whether all these peas were alike and if not, how many there were of each kind.

An Abbot's Great Discoveries

By very patient and painstaking work, carried out over eight years, he made many interesting discoveries, which had never been made before For instance, he found that when green round peas were fertilised by pollen from a plant which produced yellow wrinkled peas, the offspring in the first generation were all yellow and round. He made the experiment again and again, and the same thing always happened.

Mendel thought the matter out, and he said that the characters of yellowness and roundness were dominant over other characters, and that the characters of greenness and wrinkling were recessive, a word which means receding or withdrawing. He was the first man to use these words in this way, and they are now constantly being used by men of science all over the world.

Mendel went on with his work of crossing the pollen of different kinds of peas, and then from the results he compiled some very important and interesting statistics, which he wrote down for the benefit of other scientists. He explained how he had produced new kinds of peas, and he described the laws of inheritance which he had discovered as a result of his experiments.

He read papers on the subject to a scientific society at Brünn, and was full of enthusiasm at his discoveries. But his hearers showed very little interest, and poor Mendel was disappointed. His discoveries were really as important as Darwin's, but while the world was excited and interested in Darwin's discoveries, it took no notice of Mendel's.

However, the results of the experiments had been put on record, and the papers containing them were packed away in the library at Brünn. Fortunately, though dusty, they had remained safe, and after 34 years; that is, in 1900, sixteen years after Mendel had been buried, these valuable papers were discovered by some young scientists, who realised their importance and telegraphed the news to all parts of the world.

Scientists looked into the matter;

they tested Mendel's theories and found that he was right, and that what he had discovered explained hundreds of things in connection with animals and children that had never been understood before.

Mendel's name is now one of the very greatest in the list of nineteenth century men of science, and is honoured by men of all nationalities and classes and creeds.

The laws which he discovered from his experiments with the garden peas, and which are quite true when applied to animals, are known as "Mendel's Laws of Inheritance" or, in a shorter form, "Mendelism."

As a result of his long continued and patient experiments Mendel found that there were many characters which were dominant and many which were recessive, and he made lists of these. It is really very interesting to study Mendel's laws, and we can understand them from the pictures on page 509.

The Law of Pure Breeding

Mendel showed that when pure breds are mated with other pure breds like themselves, all their offspring are sure to be pure bred, and this will continue generation after generation so long as the parents be nothing but pure bred.

Then he showed that when a pure bred of one kind is mated with a pure bred of another kind every one of their children is what is known as a hybrid. This name is said to come from the old Latin word for the offspring of a tame sow and a wild boar and it is now always used for the offspring of two animals or plants of different species or varieties.

Finally he showed that when hybrids are mated with each other, half their offspring will be hybrid, one quarter pure bred like the grandfather, and the other quarter pure bred like the grandmother.

Since Mendel's time his experiments have been carried out by many other scientists, not only with garden peas but with animals such as rabbits, rats, mice and guinea pigs and with birds.

What Puzzled the Boy

Now we come back to the boy with his guinea-pigs. In the litter of the two black animals the proportion of black guinea pigs to white was as three to one. This does not seem to correspond with Mendel's law at all, namely, that all the offspring of two pure bred parents will be pure bred like their father and mother.

But the boy's guinea pigs really observed Mendel's law as much as the peas. The explanation of the apparent discrepancy is this, that when a black and a white guinea pig mate and have children black is the dominant colour. The colour passed on by a white and a black parent is black in the next generation, the white colour being recessive, or in other words it recedes from sight and does not appear in any member of that generation. Black, indeed, is so dominant that it drives the white entirely out of sight.

The black hybrids appear exactly like their pure-bred black parent, and when two hybrids are mated and have offspring then half of the young guinea pigs are hybrids, and will be black like pure breds, while a quarter are black pure breds and a quarter are white pure breds. If a pure bred black from this family be mated with another pure bred black their offspring are all pure bred blacks, and equally, if a pure bred white from this family be mated with another pure bred white their offspring are all pure-bred whites. The hybrids on the other hand, if mated with hybrids produce families in the usual proportions.

When the boy who had the guinea pigs had learned all this he knew at once that the two black guinea pigs which he had bought were not really pure breds at all, but black hybrids, although, of course, the dealer had no way of knowing this but really thought they were pure breds for they looked exactly like pure breds.

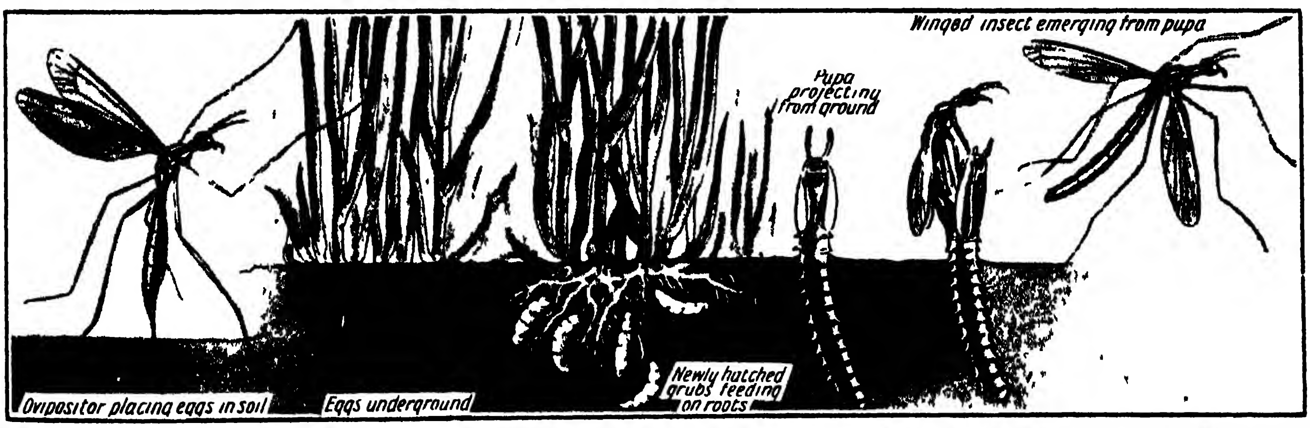
In the Case of Fowls

It is interesting to note what happens in another case. When a pure bred black Andalusian fowl is mated with a pure bred black all its descendants, as we should expect from Mendel's law, are pure bred black, and in the same way when a pure bred white Andalusian fowl is mated with a pure bred white, all their descendants are white. But when a pure bred black is mated with a pure bred white not one of their children of the next generation is a pure-bred. They are, as Mendel's law teaches us to expect, all hybrids. But none of them is either black or white; they are all a mixture of the two colours known as blue. Then when a blue Andalusian fowl is mated with another blue hybrid, half the offspring will be blue hybrids, one quarter pure black and one quarter pure white.

What may appear to be a departure from Mendel's law is not really a departure at all, for in the case of these fowls neither the colour black nor the colour white is either dominant or recessive, and so when a black and a white fowl are mated, the next generation shows neither blacks nor whites, but a mixture of the two.

Let us all honour Mendel's name.

THE LIFE-STORY OF A WELL-KNOWN GARDEN PEST



The life story of the daddy-long-legs or crane-fly, that spidery looking fly with gauzy wings, a slim body and very long legs that come off if we touch them, is an interesting one and is shown here. When the female crane-fly wants to lay her eggs she rests on her legs as shown in the first picture, bores a hole in the soil with her ovipositor, and lays the eggs underground. These are shown enlarged in the second picture. In due course little grubs hatch out and start feeding upon the roots of the grass, which perishes as a result. That is why the crane-fly is a pest. When the grub or larva is full-grown it is known as a leather-jacket, and as it lives underground it is rarely seen, unless it is turned up when turf is being cut. The larva becomes a pupa and when the time comes for the imago or winged insect to come out into the air the pupa raises itself half out of the ground, as shown in the fourth picture. This it does by means of spines on its sides. The winged insect escapes from the pupa case and flies away as shown on the right, to begin the life-story all over again. When boring into the ground to lay her eggs the crane-fly moves her ovipositor backwards and forwards as a carpenter does a bradawl when he is boring a hole. It is in the leather-jacket stage that the crane-fly is such a nuisance, doing great damage to our lawns.

GATHERING THE CACAO PODS TO MAKE COCOA

Cocoa has nothing to do with the coconut palm or the coca plant from which the drug cocaine comes It is obtained from the fruit of the cacao tree, whose botanical name means "The Food of the Gods" The cacao tree is a native of South America, but it is now grown in other tropical lands, including large areas of Africa and Asia The tree begins to bear fruit when five years old ; and the green pods which are attached to the trunk and branches by short stalks and look like thick cucumbers, are about eight or nine inches long As they ripen they turn first red, then yellow, and when dried become a chestnut brown The lower pods are gathered by hand and the upper ones are cut from the stem by a small knife fastened to a long stick. The man in the picture is using such an implement The seeds in the pod are the cacao beans of commerce which are ground up to make cocoa and chocolate

LIFE ON THE EARTH EIGHT MILLION YEARS AGO

On the left our artist, Miss Betty Nation, shows the kind of life that existed in the Permian period of the world's history, perhaps 8 million years ago, when there was a great uplifting of the Earth's crust, and Africa and South America first appeared It was the age when giant tree-ferns flourished, but cone-bearing trees began to appear Amphibians were developing into reptiles These Permian reptiles were only a few feet long, but they were the beginning of life on land Some of them had spiny crests down their backs Fish, which in earlier ages had been the highest living creatures, had now lost the lead In many Permian fishes the tail was becoming symmetrical, as in our living fishes of to-day The Permian age brought to a close the Palaeozoic or earliest life epoch of the Earth's history On the right we see life in the Triassic period, which succeeded, and which began perhaps 7 million years ago Of course, geologists vary enormously in estimating the duration of the various geological periods, but we have taken a conservative estimate In the Triassic age there were many kinds of trees as well as ferns and in addition to invertebrate types many new vertebrates were appearing There were ichthyosaurs or fish-lizards, large land reptiles, and the very earliest mammals. Of the form of these mammals, however, we know nothing

THE HORNBILL CATCHES AN APPLE IN ITS BEAK

The hornbill gets its name from the appearance of its enormous beak, which has on top a growth known as a casque This is sometimes very large and prominent, and at other times more like a compressed keel as in the case of the bird in the picture, which has just caught an apple in its beak Owing to the size of the bill the bird looks quite top-heavy, but as a matter of fact the beak is very light, being mostly hollow, and does not interfere with the bird s flying Hornbills, of which there are several species all inhabiting the Old World Africa, India, Malaya, and some of the Polynesian Islands are omnivorous, and devour large numbers of mice, small birds, beetles, worms and so on Five or six hornbills will even attack a snake and worry it till it dies When the snake advances the hornbill protects itself by folding both its wings in front of its body The African hornbill s call note sounds like Coo coo and is so loud and distinct that it can be heard for a distance of two miles The nests are built in hollows in trees

PLANTS WHOSE BEHAVIOUR SEEMS TO EXHIBIT INSTINCT

PLANTS often move and act in their own interest in such a marked and definite manner that we might almost say they exhibit instinct Indeed Anton Kerner the famous German botanist definitely says that plants possess instinct and he advances as evidence for this belief the fact that many plants exhibit movements that are purposely adapted to their own advantage

What is instinct he asks but an unconscious and purposeful action on the part of a living organism?

He goes on to explain that we have instances of its working in every spore in search of the best place to settle in and in every pollen tube as it grows down through the entrance to an ovary and applies itself to one definite spot of an ovule never failing in its object

The water crowfoot for example in deep water fashions its leaves with finely divided tips large air passages and no stomata while when it grows above the surface of the water its leaves have broad lobes contracted air spaces and numerous stomata In other words it suits itself to its surroundings

Stomata are very small openings or pores in the surfaces of plants

A remarkable example of this kind of instinct in plants is furnished by a plant known as Linaria cymbalaria, which grows on stone walls and similar places When it flowers it raises its flower stalks from the wall towards the light so as to get as much sunshine as possible As soon, however as fertilization has taken place, the stalks begin to curve back toward the wall so that the seeds may be deposited in cracks and crevices where they will be protected and eventually germinate

A plant s action that seems to suggest instinct The linaria bends its branches with the seed-heads towards the crevices of walls and shakes the seeds into the cracks, thus ensuring their safety

MARVELS of MACHINERY

WHY MACHINES CAN BE MADE OF METAL

Engineering triumphs are among the greatest wonders of the world to-day. In fact, the engineers seem to be able to make machines to do practically anything except think. Yet they would be quite helpless were it not for the fact that the metals of which they make their machines possess properties which enable them to be hammered or pressed out thin, and also drawn out in the form of wire. We could have no electrical machinery without wires. Here we read many interesting facts about these properties of metals.

IT is certainly a very fortunate thing for mankind that the metals possess two properties which are known by the rather difficult terms "malleability and ductility." They stand for quite simple things. Malleability comes from the Latin word "malleo," which means "I beat with a hammer," and when we say a metal is malleable we mean that it can be shaped or extended by being beaten with a hammer. Ductility comes from the Latin word "duco," "I lead," and to say that a metal is ductile simply means that it can be led or drawn out into wire or threads.

If it were not for these two properties of metals the engineers would not be able to make the wonderful machines which they now produce to do all kinds of work for us. It is because metals can be beaten and rolled and drawn out that the parts which make up the machines can be formed.

A Wonder of Gold

Of all metals gold is the most malleable and ductile. It can be beaten into plates or leaves so thin that it takes 300 000 of them placed one above another to make one inch and the gold is then transparent enough to allow rays of light to pass through. Aluminium can be beaten to the 50,000th of an inch, and copper to the 30,000th of an inch.

It is, however, in a metal like iron that this malleable quality is so valuable. Of course, in the old days iron was beaten out with a hammer by hand, for the first metal working tool was a hammer, the head of which consisted of a flint. Nowadays, hand beating is carried out principally in the making of ornamental ironwork and in the making of a few small articles such as horseshoes. We have no doubt stood in a blacksmith's forge and watched him beating out the red hot horseshoe on the anvil.

Nowadays enormous masses of iron and steel can be beaten or rolled out by huge hydraulic hammers or by great rolling mills. When the steel ingots are cast at a steel works they are, while in the hot and plastic state, passed through a rolling mill where they are squeezed into sheets or bars or any form that may be required. This pressing of the metal improves it, as it squeezes it into a more solid and durable substance.

Armour plates and the tubes for big guns and similar articles are forged in hydraulic presses, and this is done slowly, as much better results are obtained by slow forging than by rapid work. The large parts of engines and machines are beaten out by steam or hydraulic hammers, and smaller parts are generally forged into shape by drop hammers. This corresponds to beating, whereas the slow moving presses squeeze the metal.

If metals like iron and steel were not malleable they would of course break when struck and crack when rolled or pressed. Their malleability makes it comparatively easy with the huge modern rolling mills which are found in all steel works to make bars and rails and sheets of an absolutely uniform thickness throughout.

In this picture we see gold being rolled out into thin sheets. It is one of the most malleable of metals, and sheets or leaves of gold can be made so thin that they are only one 300,000th of an inch in thickness and are transparent

In the Rolling Mill

The red hot metal is passed through very heavy rollers, shaped according to requirements, then it passes through a second pair of rollers and so on till it is of the required size and shape. In the rolling mill a plate is rolled out in stages, passing from one pair of rollers to another pair where the rollers are closer together so that the plate becomes thinner and thinner till at last it is of the required thickness.

It is very much the same sort of operation as the housewife performs when she rolls out the pastry on a pasteboard. She throws on the board a thick lump of plastic dough, and rolls it out again and again until it is more or less uniform in thickness and thin enough to go on the pie.

In some of the large rolling mills the steel may start as a thick lump

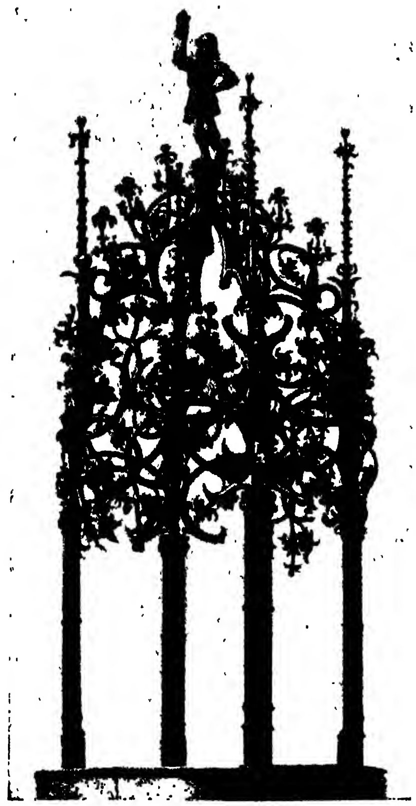
of metal weighing more than a hundredweight, and it may be rolled again and again until at last it is changed into rods or sheets a sixteenth of an inch thick or even less

The ingots of steel which are cast for the making of tools are generally about a hundred pounds in weight But those which are used for the manufacture of steel rails and plates average six tons in weight and are usually six feet long with a section two feet square Sometimes, however, they are as much as ten tons, or even more For special work, however, the ingots are cast to a size suitable for the rolling mill in which they will be pressed out into shape.

When an ingot is rolled out the change in shape is mostly an addition to the length The piece of steel does not become very much wider. The metal is not rolled out always in the same direction, for it is found that if this is done it usually becomes weak, and experiments have proved that bars cut from metal with their axes lying in the same direction as the extension of the metal when it is rolled are much stronger than if they are cut in the other direction

The methods of dealing with metal in the engineering shops have been brought to perfection in recent years, and full advantage is taken of the malleable and ductile qualities of the metals

The malleability of metals varies a great deal as has already been indicated.



The beautiful beaten ironwork canopy over an old well in Antwerp, made by Quentin Matsys, a 15th century painter

Antimony, for example, cannot be thinned out by hammering It invariably breaks. We know how fragile it is from those small cheap boxes and caskets that are sold, and which, if they are dropped on a hard surface, break up as though they were made of earthenware or glass.

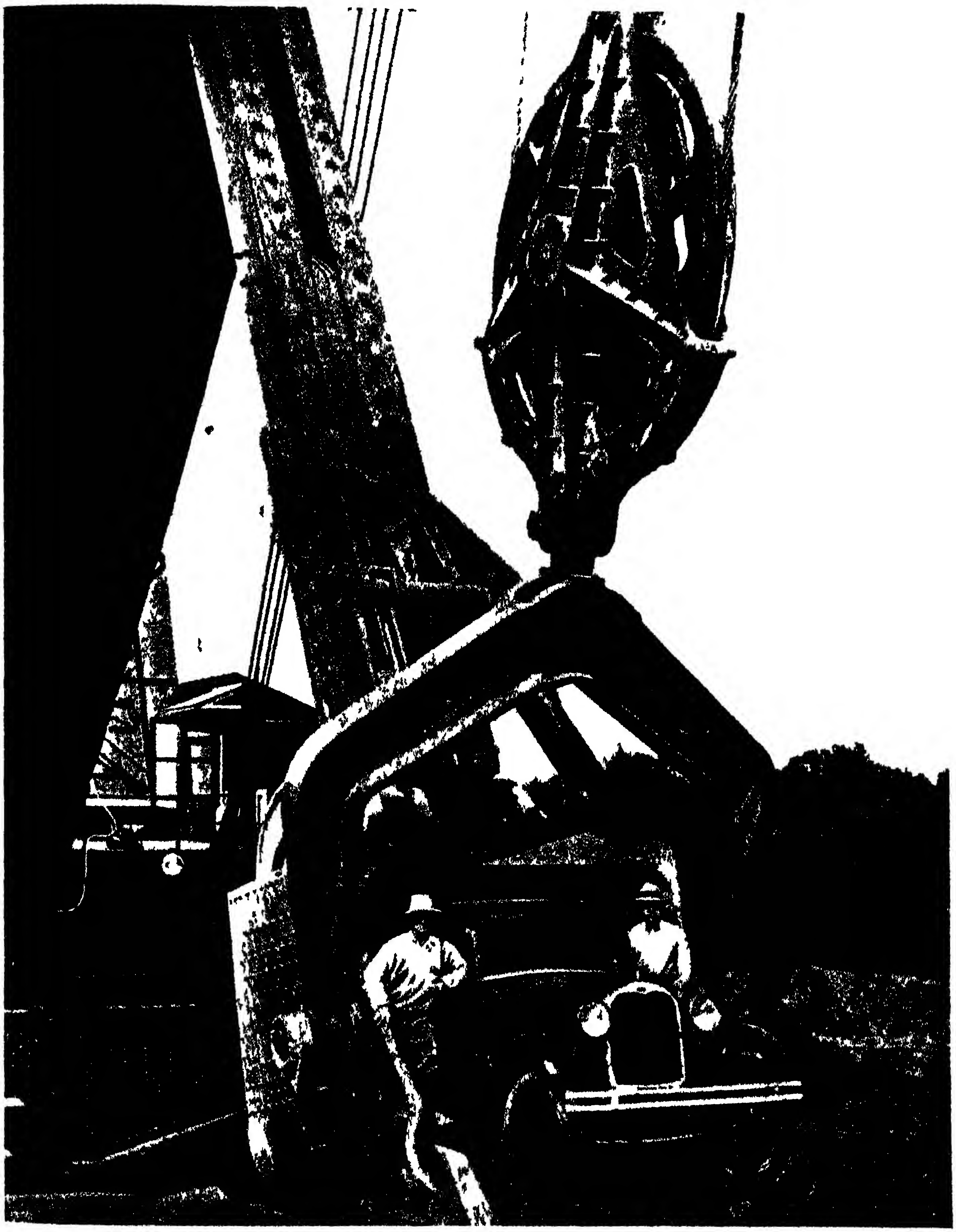
Cast iron, too, is generally brittle although it may be made less so when it is heated for some hours with black iron oxide. During this process some of the carbon is removed from the cast iron, and it then becomes much more like wrought iron. It is the impurities in the cast iron, such as carbon, silicon and sulphur and phosphorus that make it brittle.

When wrought iron is manufactured from pig iron it is heated in a furnace lined with substances like hematite or magnetite, which supply oxygen to burn out the carbon, silicon and other impurities. When the hot, pasty production is worked under a steam hammer or in a rolling mill further impurities such as slag or earthy dross are squeezed out of it.

There is a malleable iron which is a cheap substitute for wrought iron, and it is made by embedding the cast metal in iron oxide and then heating it for about two days, after which it is cooled off slowly. Some of the carbon is in this way removed from the cast iron, making it less brittle. Absolutely pure iron is not obtainable as a commercial product.

A blacksmith at work making ironwork scrolls by beating them into shape with a hammer on his anvil. The hammer was the earliest of all metal-working machines. Now there are steam hammers for forging metal, the falling part of which in some cases weighs 100 tons

THE BIGGEST SHOVEL IN THE WORLD



What would the men of old have thought of this gigantic steam shovel? It can dig up a hundred tons of earth at one scoop and lift it 85 feet above the ground that is to the height of a seven-storey building Its enormous size can be judged from the fact that a motor-car can be put right inside the shovel This tool is used in America for moving coal, and we can quite understand that an apparatus of this kind displaces a large number of manual labourers It can be worked with ease by one or two men and the scooping up of the hundred tons of material and the placing of it elsewhere is carried out in a few minutes It does the work of hundreds of men

A RAILWAY THAT RUNS WITHOUT DRIVERS

THERE have been many suggestions for relieving the congestion caused by the ever increasing traffic in the streets of London and one of the most sensible is that underground tubes should be constructed and that all heavy goods should travel through these tubes instead of above ground This would leave the roadways in the streets free for passenger traffic and for the carriage of light goods together with the delivery of heavier goods to their owners from specified stations

This may seem a gigantic and costly proposal but as a matter of fact it would be less costly than one might think It is not an untried scheme for already the General Post Office has an underground railway of this kind for the transport of mails in London

This Post Office tube railway runs 70 feet deep for six and a half miles under the streets of London between Whitechapel and Paddington and in addition to these end stations there are also stations at Liverpool Street the General Post Office itself the Mount Pleasant Sorting Office the West Central Sorting Office the Western Parcel Office the Western Letter Office and the Paddington Sorting Office

The trains which run on this unique railway have no drivers They are entirely automatic and yet they travel at 35 miles an hour and carry about 30,000 bags of mails every day Even if the quantities of letters and parcels sent by post should increase enormously they could be dealt with by this railway for it has been designed for a two minute service

Already a large number of vans have been taken off the streets as a result of the installation of this railway, for as the Post Office officials put it the street congestion has been relieved of 1 300 van miles a day That means that vans which used to travel in the streets for a total distance of 1 300 miles every day carrying mails have disappeared The automatic railway does their work

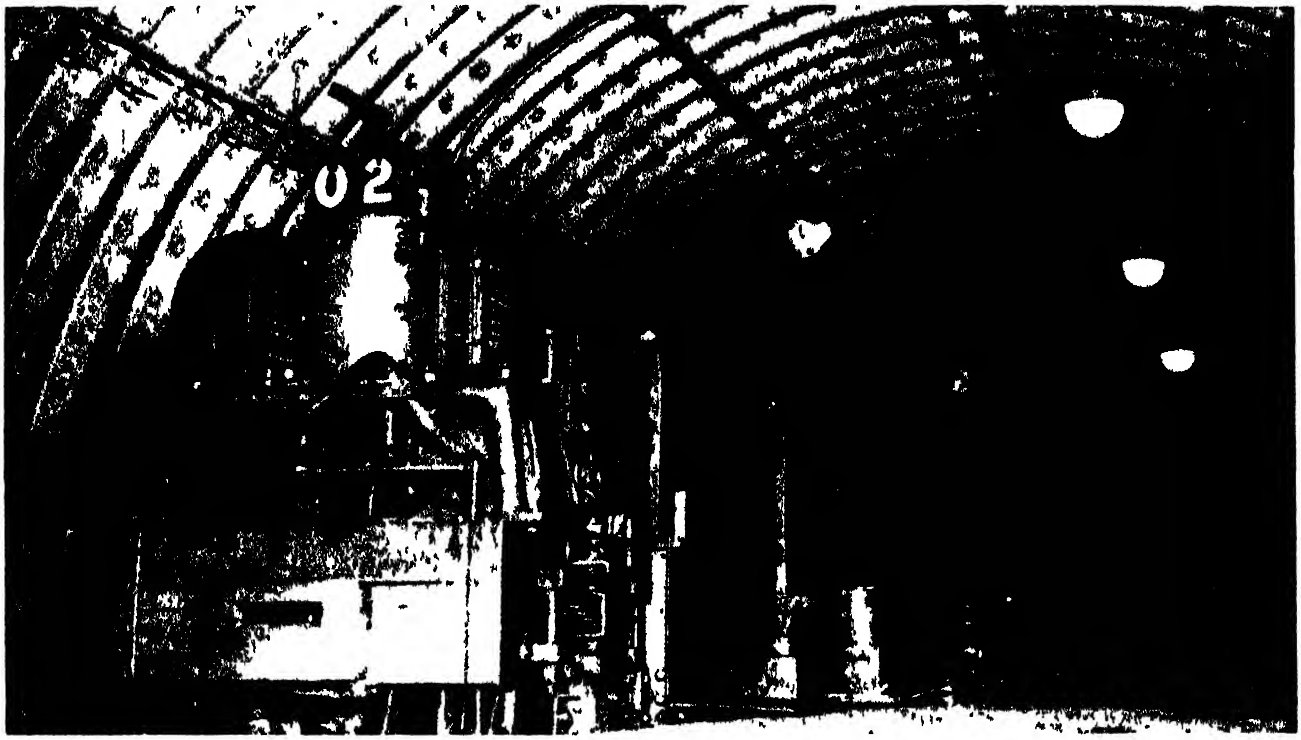
At each of the eight stations there are conveyor buckets for taking up the mails when they arrive, and spiral chutes for sending them down when they are to be despatched There are platforms at the stations for loading or unloading the trains, and these vary in length from 90 feet to 313 feet The staff reach the stations by automatic lifts

The railway is of course, much smaller than an ordinary tube railway for passengers It is like some of those miniature railways that are found in different parts of the country The line has a two-foot gauge and the tunnel in which there is a double track is nine feet in diameter At the approaches to the stations the track is divided and each part runs in a separate seven foot tunnel At the stations there are two sets of tracks each way so that there can be a slow and fast service some trains running right through the stations without stopping

Of course the whole railway is electrically worked, the electricity being taken up by the train from a central rail The driverless trains are controlled from cabins by switches, very much in the same way as signals are worked No signals, however, are needed as instead of raising or lowering a signal so that a train can be stopped or sent on, these trains are started and stopped directly The switchmen in the control cabins watch the progress of each train through their sections on illuminated diagrams, and can bring any one or all of the trains to a standstill when required by cutting off the electric current

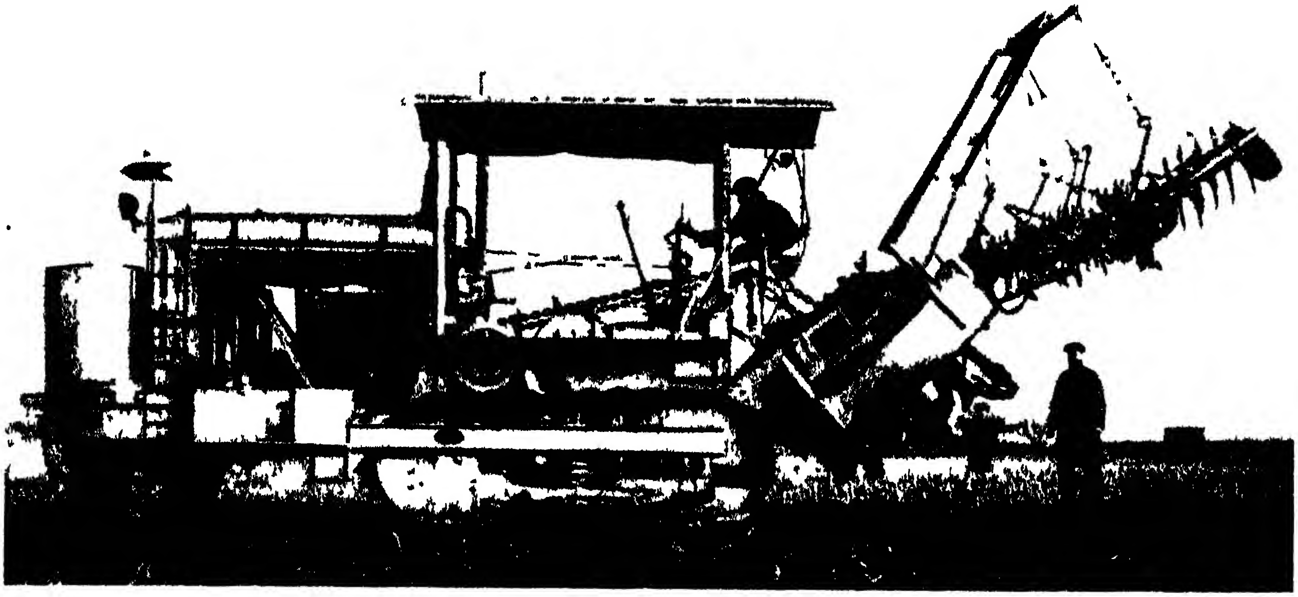
Each train is made up of three cars, and there are ninety cars altogether on the railway

This wonderful railway was begun in 1913 but progress was stopped during the 1914 18 War, when the tunnel was used for the storage of national art treasures which were in danger from aerial bombardment The railway cost £1 500 000, which was a remarkably small sum for such an extensive and efficient system of transport If a more extended system for ordinary goods traffic all over London could be constructed at anything like a proportionate cost, it would be a cheap way out of the difficulties and delays of congested street traffic A somewhat similar underground railway system, but not completely automatic, has been built for the carriage of general merchandise in Chicago, U S A.



One of the G P O 's automatic mail trains being unloaded at Mount Pleasant Station, London

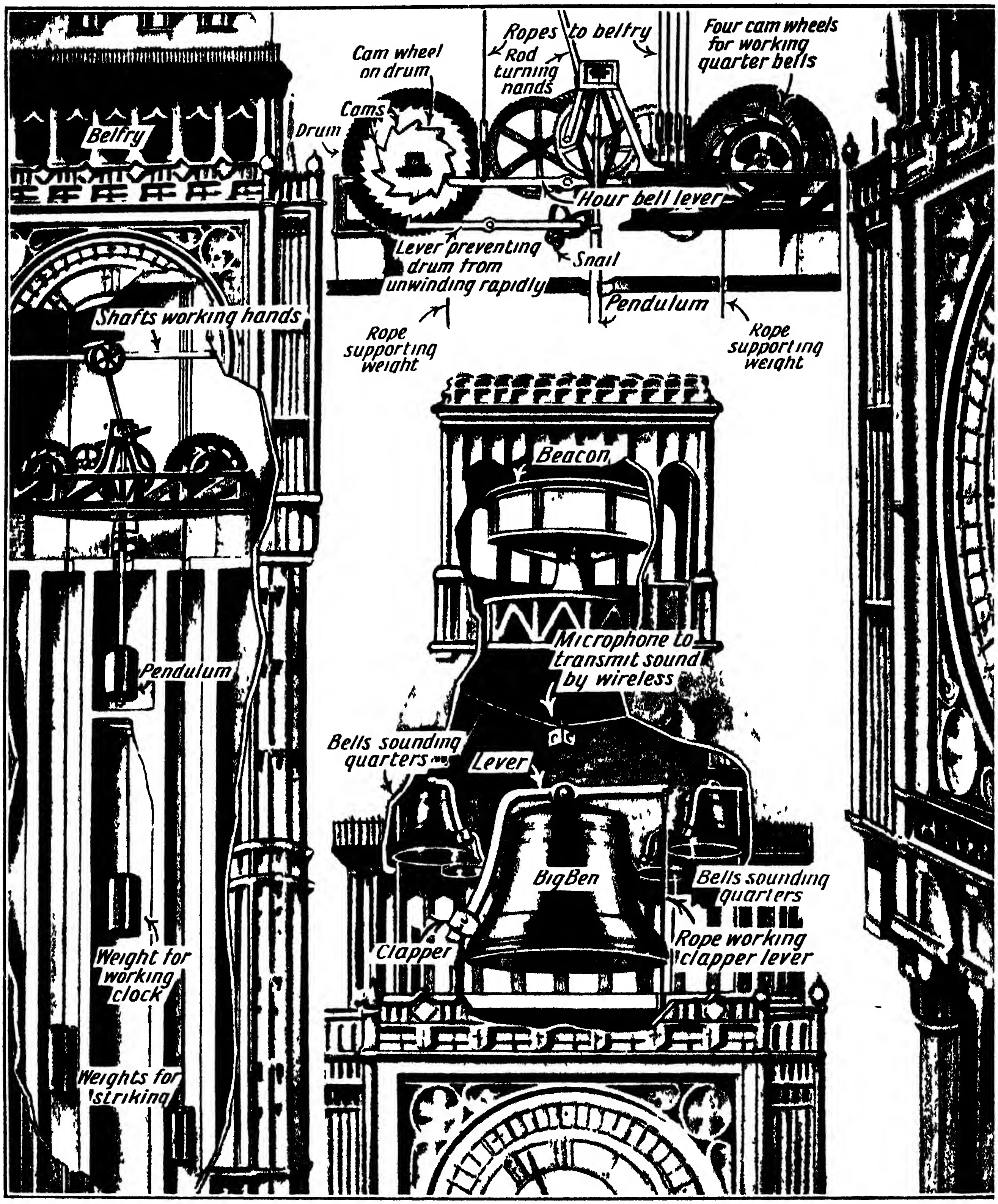
NEW & OLD WAYS OF PREPARING THE SOIL



In no branch of industry has machinery made greater strides in a short time than in agriculture A century ago all ploughing, even in the most advanced countries, was done with a comparatively small plough drawn by horses and guided by a man holding the handles Then exactly a hundred years before this book was written the steam plough was invented by an English Member of Parliament named John Heathcoat, and from that time to this the development of agricultural machinery has gone forward by leaps and bounds The extent of the improvements in a century can be seen by contrasting the two pictures on this page Here we see what is known as a gyro-tiller at work on an Essex farm It ploughs and harrows at one operation and can complete an acre in one hour Seven powerful electric lights on the machine enable work to be carried out at night as rapidly and efficiently as in the daytime

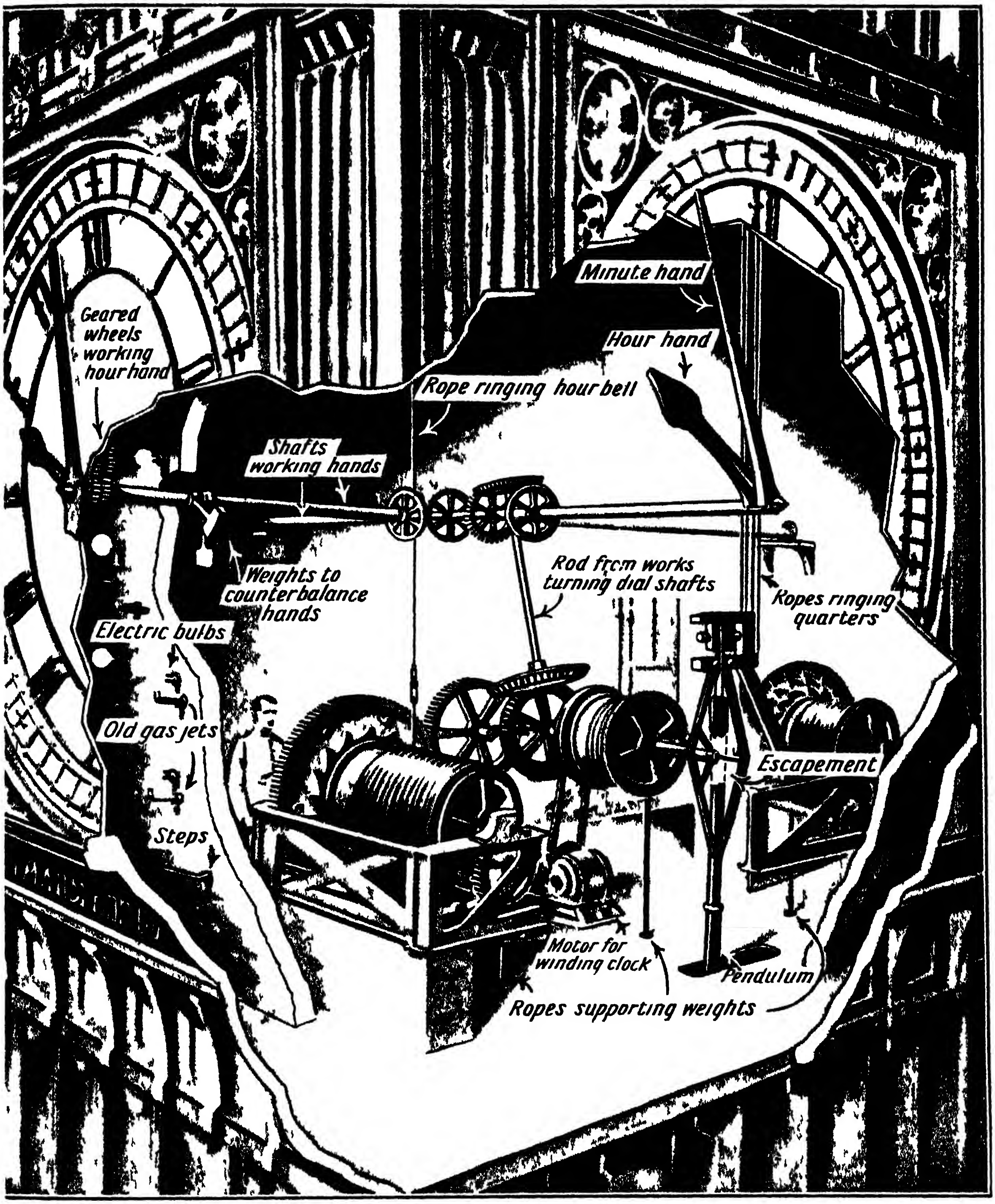
In this picture we see ploughing being carried out to-day very much as it has been done in England for hundreds of years The plough is drawn by horses and guided by the man in charge of the team If the land is to produce crops the soil must be prepared, and this is done by breaking up the earth and exposing the clods to the effect of air Sun and rain Ploughing has always been one of the most important of human operations The width of the furrows or trenches made by the plough vary according to the character of the soil After the land has been ploughed it has to be broken up into smaller fragments, and this is done by a machine called a harrow, which consists of a frame with iron teeth that is drawn across the ground Sometimes a different machine, called a cultivator, with prongs is used The machine in the upper picture does the ploughing and harrowing at one operation

HOW BIG BEN WORKS AND STRIKES



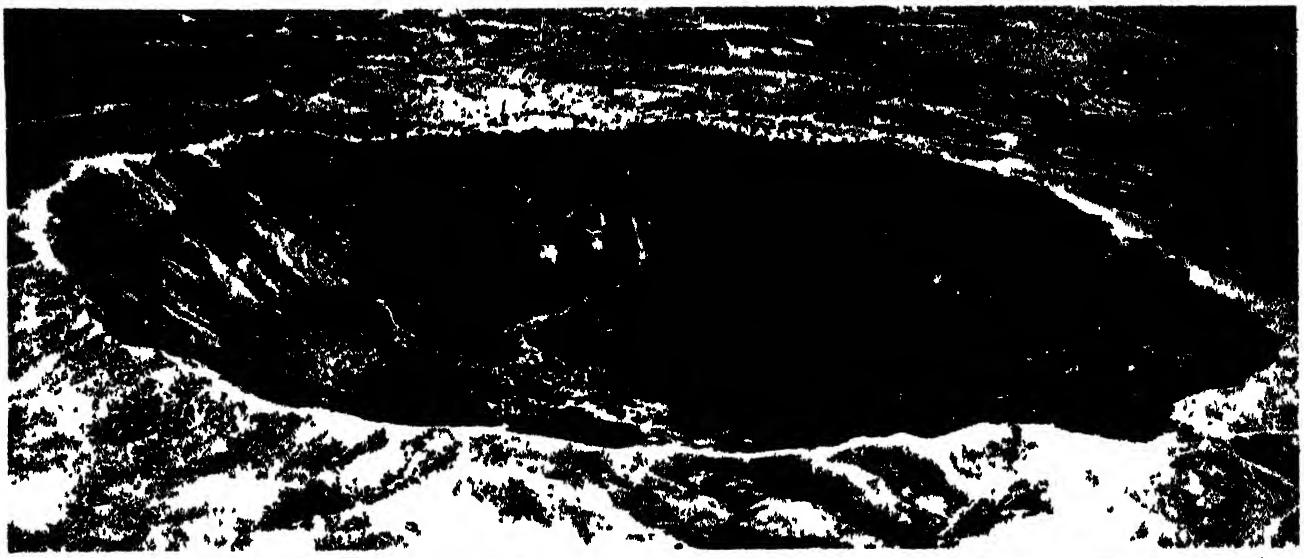
By the courtesy of the Office of Works and the Lord Great Chamberlain's Department Mr L G Goodwin has been permitted to make sketches in the Clock Tower of the Houses of Parliament and here we see how Big Ben works The power that works the huge clock is provided by heavy weights of nearly two and a half tons These are suspended on wire ropes wound round drums, and the weights run down nearly the whole length of the Clock Tower In the right hand picture we are shown how the hands are turned by the clockwork The drum in the middle is slowly revolved as the weight goes down and is regulated from going too fast by an escapement in the form of a fan with three arms As the drum turns it works a series of toothed and bevelled wheels which turn a shaft and this again, by means of another series of toothed and bevelled wheels, turns the shafts that work the hands Each of these shafts consists of an outer tube which works the minute hand and an inner rod which works the hour hand The hands are so heavy the minute hand being fourteen feet long and weighing two hundredweights, and the hour hand nine feet long and weighing even more although shorter that they have to be counterbalanced The upper picture on this page shows the principle on which the striking is

SO THAT ALL THE WORLD CAN HEAR

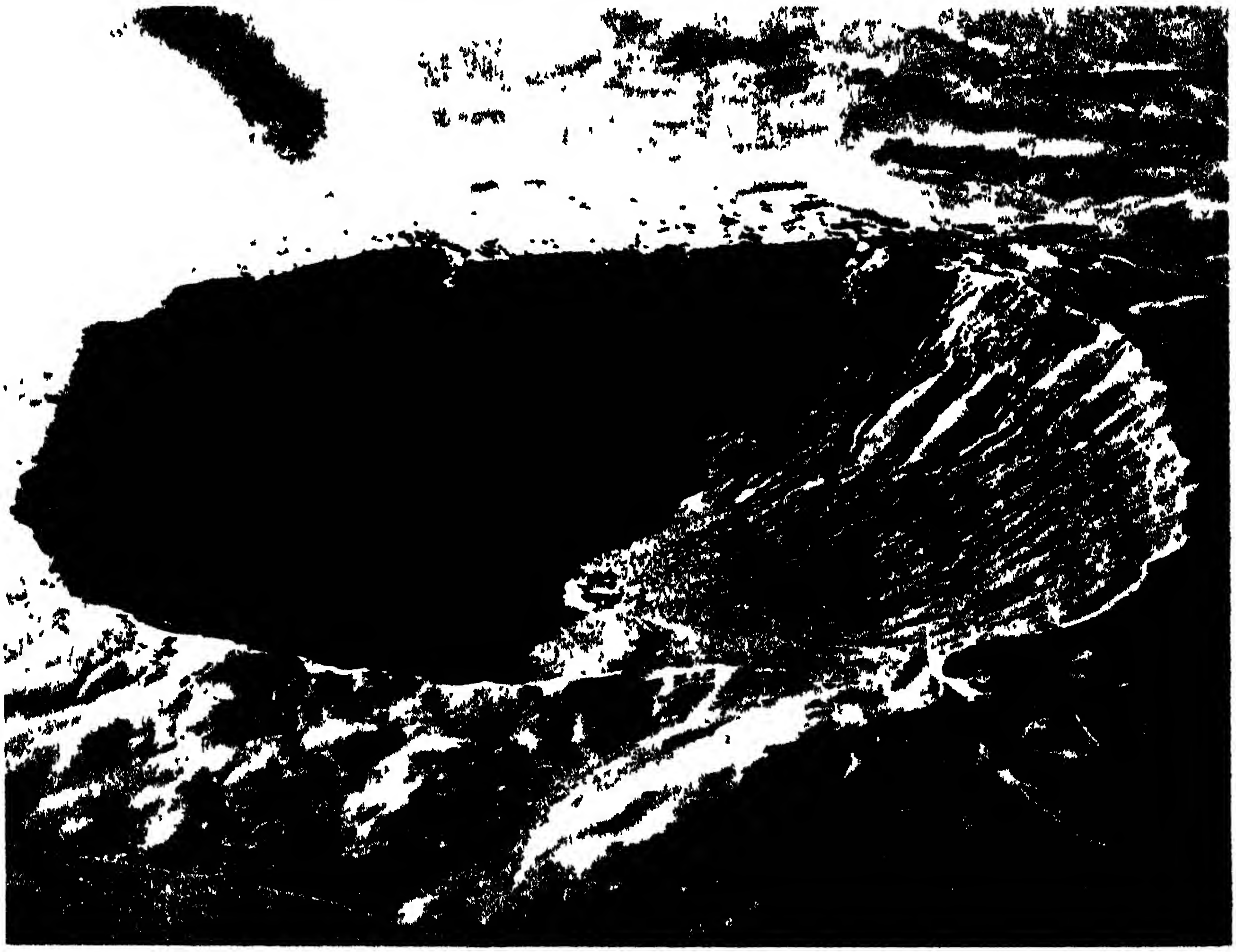


done. By an elaborate series of toothed wheels and cams too complicated to show in detail a lever is operated which pulls the rope and moves the clapper, so that it strikes the bell. The drum on which the rope revolves is prevented from going round too fast by another lever which is operated by the clockwork and holds the wheel, only releasing it at the required intervals for striking the bell. The end of this lever is worked by a form of cam known as a snail. For chiming the quarters another drum has a similar arrangement multiplied four times. The drawings are greatly simplified to show the principle, but it is impossible to show all the details for chiming and striking. The desired result is obtained by a train of geared wheels and an arrangement of cams. The clock is wound up by an electric motor and lighted by electric lamps. The dials of Big Ben are twenty three feet in diameter and their centres are 180 feet from the ground. The figures are two feet long and the minute space is a foot square. The pendulum is thirteen feet long and weighs four hundredweights. Big Ben, the bell, weighs 13½ tons and the hammer four hundredweights. The four bells which chime the quarters are all of different sizes and weigh altogether eight tons. This picture should be studied with those on page 315

WHERE A 14,000,000-TON METEORITE HIT THE EARTH



Thousands of years ago a great meteorite struck the Earth in Arizona The tremendous impact of the white-hot mass made a hole about 600 feet deep and nearly a mile across Further the blow as the meteor struck the Earth threw up all round the crater a great rim that stands about 160 feet above the level of the surrounding plain This photograph, printed here by the courtesy of The Engineering and Mining Journal, gives a very good idea of what the Meteor Crater as it is called, looks like when viewed from the air The great Swedish scientist, Arrhenius called this "the most interesting spot on Earth"



Here is another view of the Meteor Crater in Arizona, as seen from the air, published by courtesy of the Carnegie Institution For more than twenty years engineers and scientists have been trying to locate the buried meteorite, and more than £100,000 has already been spent in borings It has recently been announced that the searchers have come upon some metal about 700 feet below the present crater floor The reason for searching for the meteorite is not purely scientific It is believed that the metal alone will be worth millions of pounds One scientist estimated that the meteorite must have contained at least 14 million tons of iron

WONDERS OF THE SKY

STRANGE MESSENGERS FROM SPACE

It has been estimated by astronomers that between ten and twenty million meteors enter the Earth's atmosphere every day. Most of these are burnt up owing to the intense heat generated by friction with the air. But now and again fragments reach the Earth, and are known as meteorites. On several occasions giant meteorites have reached the Earth, but never has one of these big missiles struck a city or an inhabited region. This is lucky for the dwellers on the Earth. Here we read many interesting things about meteorites.

On the night of June 30th, 1908, some observers in England noticed that the sky was so brightly lighted up that they were able to read out of doors at midnight. This unusual glow in the sky was not due to a display of the Aurora Borealis, so what could have caused it? No one could say at the time, although certain seismographs registered earth tremors, and some delicate instruments known as microbarographs, which show small changes of atmospheric pressure, recorded a series of waves.

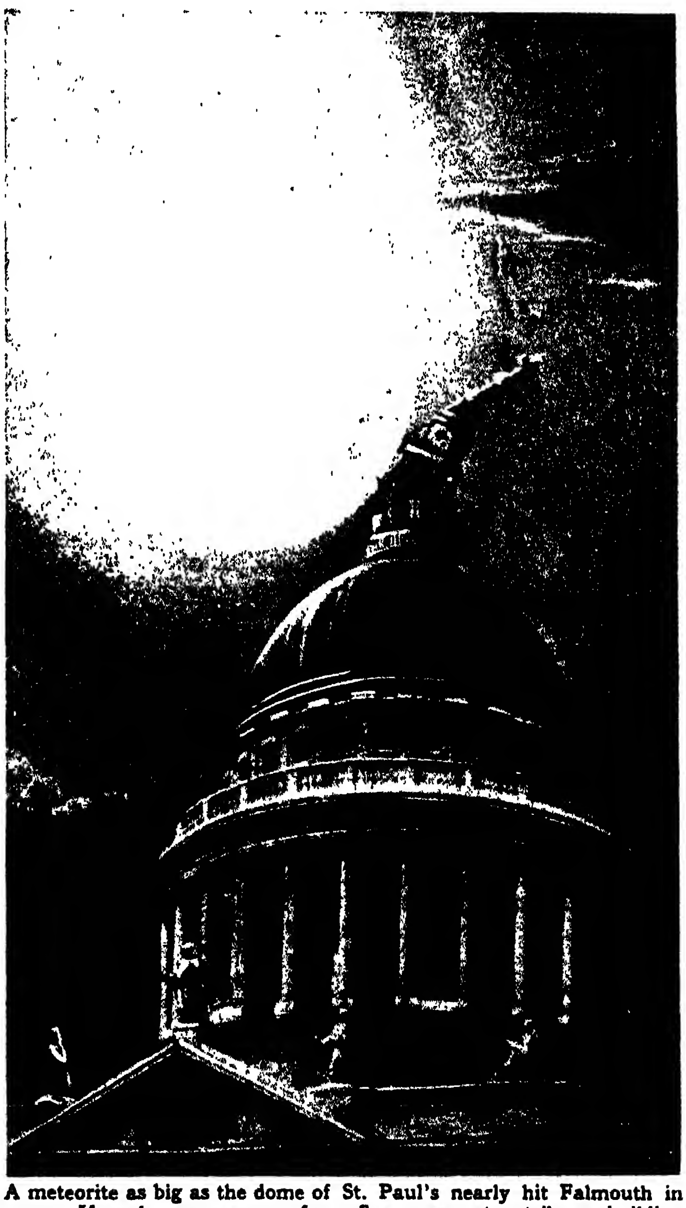
It was some years before the explanation was discovered, and then some Russian scientists found that on the night of June 30th, 1908, an enormous meteorite, crashing through the air like a huge ball of fire, had struck the Siberian Forest 500 miles north of Irkutsk, completely devastating an area of a hundred square miles.

Scarcely a tree was left standing, and at the place where the meteorite struck the Earth a crater-like depression as big as Kent and Essex put together had been left. The tremors set up by its impact were felt three thousand miles away, and the sounds of the bombardment were heard six hundred miles away.

If this meteorite had struck London it would probably have wiped it out, for not only does the rushing wind which a meteor creates lay everything low for miles around, but the meteorite itself, heated intensely by the friction with our atmosphere, explodes owing to the sudden expansion of the gases within it.

In 1950 a prospector named Frederick Chubb was searching for gold in a district of northern Quebec between Hudson Bay and Ungava Bay when he found a crater with a circumference of 6½ miles and 1,350 ft. deep. Scientists later established that the crater, called the Chubb Crater after its discoverer, had been made by a huge meteorite which fell on the ground between 12,000 and 15,000 years ago.

When it struck the earth the meteorite exploded and in addition to blowing the crater in the ground threw up a rim of granite rocks 550 feet high. The middle of the crater is filled by a perfectly circular lake 850 feet deep. The meteorite must have struck the earth at a steep angle, as the crater is like a tilted cup, with one side considerably higher than the other.



A meteorite as big as the dome of St. Paul's nearly hit Falmouth in 1929. If such a messenger from Space were to strike a building like a cathedral in the centre of a big city it would not only wreck it but probably destroy a great part of the city as well.

Another huge meteorite struck what is now the State of Arizona in America, and made a crater 4,000 feet across and 550 feet deep. Some tons of meteoric iron have been found in and about the crater, and borings have been made to get at the great mass of the meteorite that probably lies below the ground. Scientists tell us that this Arizona meteorite had a diameter of about 400 feet and weighed 14 million tons.

Other large meteorites have been found, though not comparable to these in size and weight. Captain Peary, the Arctic explorer, brought from Greenland a large iron meteorite weighing 36½ tons, which is now in the American Museum of Natural History.

In the Natural History Museum in London is an iron meteorite weighing 3½ tons, found in 1854 near Melbourne, Australia.

Men of science have estimated the number of meteorites which actually strike the Earth's surface every year, and the estimates vary between 700 and 4000. Even if we take the smaller number it seems marvellous that these messengers from

Space always seem to strike some uninhabited part of the Earth or fall into the sea. There is no record of any person having been killed by the fall of a meteorite.

Nevertheless there have been some narrow escapes. On the evening of December 28th, 1931, an enormous meteor was seen in the sky above the city of Lisbon. It passed over the city with a roar like an express train and the country round was lighted up for miles. Observers declared that the meteor appeared about three times the size of the Moon as it is seen in the sky. It was then probably from 50 to 80 miles above the city, and fortunately it missed the city and seems to have hurtled into the Atlantic Ocean.

Little more than two years before, namely in the early morning of July 28th, 1929, a similar meteorite appearing many times brighter than the full Moon was observed rushing over Cornwall not far from Falmouth. It first of all shone with a greenish blue light which changed to orange yellow. A succession of loud explosions was heard in places as far apart as Penzance, Fowey and Liskeard. Fortunately this also passed over the town and finally dived into the sea. Astronomers who analysed the various reports of observers calculated that it had a diameter of about 150 feet when first observed, and so must have been bigger than the dome of St Paul's Cathedral.

A Capital in Danger

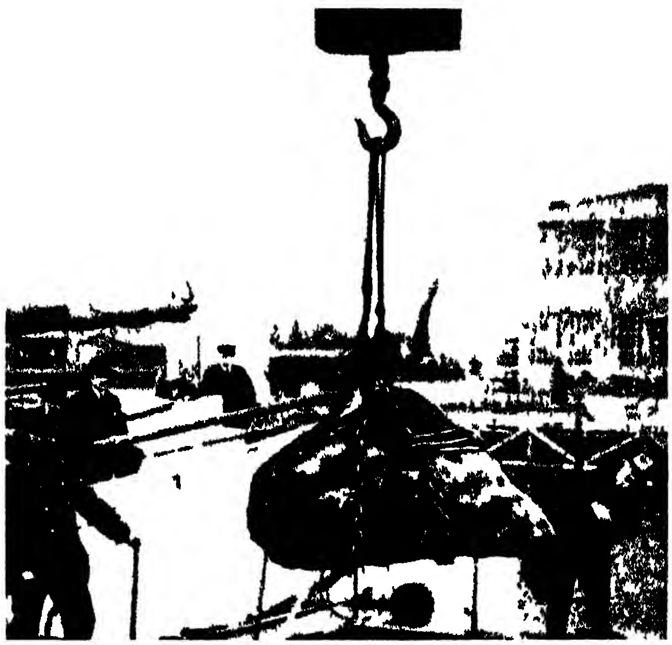
In 1896 a panic was caused in Madrid by the bursting of a meteorite just over the city. It was on the morning of February 10th at half past nine during fine sunny weather that the sunlight became suddenly dimmed and then a thunderous crackling sound was heard as though thousands of cannon were being fired off together.

The Earth trembled, some buildings were damaged and many window panes were shattered. Some people thought it was an earthquake, others that a powder magazine had blown up, but the real cause of the trouble was the bursting of a meteorite at a height of about 18½ miles above the city. Most of it went off as dust in the air, but a shower of stones fell on the city, and several people were injured.

It is not surprising that people were alarmed as they were in the old days. Many people think that the statement in the tenth chapter of Joshua in the Bible, "The Lord cast down great stones from Heaven," refers to a fall of meteorites, and Livy the Roman historian tells how it rained stones on the Alban Mount.

On the night of November 27th, 1919, a giant meteorite was seen by numbers of people to fall into Lake Michigan. It appeared first as a great ball of fire, white and orange in colour, and then as it hit the water a pillar of flame a hundred feet high was seen. There was a great roar as it rushed through the air, and when it struck the water the Earth trembled.

What are these strange messengers that come to our Earth out of Space? We have already seen on Page 110 that millions of meteors or shooting stars that flash across the sky and are burnt up in our atmosphere every year are fragments of comets, and these larger masses may have the same origin. On the other hand some astronomers believe that they have in some distant age been shot up out of volcanoes on the Earth or the Moon or one of the planets. A speed of six miles a second is sufficient to carry a body beyond the reach of the Earth's gravitation, and a body shot up from the Moon with the speed of a mile a second would leave that satellite for ever.



A giant meteorite that fell in Denmark long ago. It is now to be seen in a Copenhagen museum

A Violent Return to Earth

It is therefore quite conceivable that matter ejected by violent volcanic eruption on the Earth or on the Moon in former times might have been set travelling through space. Then in some way they might have come again within the reach of our planet's attraction and so have been brought to Earth in the dramatic manner described.

Other astronomers think that these huge meteorites may be fragments of the Sun or of some heavenly body broken off in long distant ages. Still another theory is that of Sir Norman Lockyer, who believes that all the suns and planets originated in meteors, which became massed together and grew bigger and bigger as more and more meteorites came together. Whatever their origin they are a very real fact.

Various names are given to these strange visitors. They are generally called meteorites, a word which means something raised on high, but they are also called bolides, which simply means missiles. Then scientists give them special names according to the material of which they are made. A meteorite consisting chiefly of iron is a siderite, from the Greek word sideros, meaning iron. One composed of iron and stone is called a siderolite, a word made up from the Greek words for iron and stone, while those which consist almost wholly of stone are known as aerolites, which simply means air stones. When the fragments are burned up in the Earth's atmosphere and never actually reach the ground in solid massive form they are generally called meteors.

The late Lord Kelvin thought that the germs of life might have reached the Earth by means of meteorites, but there is no evidence whatever of this. No organic traces have ever yet been found in meteoric stones.

A Thin, Black Crust

When it reaches the Earth a meteorite has a thin black crust covering its outside. Sometimes this is glossy like varnish. It is caused by the fusion of the surface during the meteorite's rush through our atmosphere. Generally there are pits and hollows which are known as thumb marks, because they look like the marks made by the pressing of the thumb into soft putty. They are believed to be due to the burning up of the more fusible substances.

In 1868 at Pultusk in Poland the fragments of a meteorite which fell there were said to number over one hundred thousand, and these varied in weight from 500 pounds to a few grains, the whole weighing over a ton.

The crash like that of thunder which accompanies the arrival of a meteorite is partly due to the sudden rush of air into the space traversed by the meteorite and partly due to the mere rush of the missile through the air. Then the explosion of the meteorite sounds like the bursting of a bomb and the rolling sound following the detonation is due, like thunder, to the echoes from the ground and clouds.

About thirty chemical elements have been found in the meteorites that have struck the Earth, but no new ones

THE POOR LITTLE NINE DAYS' QUEEN

The story of Lady Jane Grey, who was forced upon the throne of England against her will and, as a result, lost her head on the scaffold, is one of the saddest in English history. She was the granddaughter of Henry the Eighth's sister, and so had Tudor blood in her veins. But she had no right to the throne, as others came before her, and those who made her Queen were seeking only their own interests. The gentle, clever little girl reigned for only nine days. Here is the pathetic story.

When Henry VIII died his poor little weakling son Edward, the child of his third wife Jane Seymour, came to the throne. He was only ten years old, so obviously though he reigned he did not rule. The Government of the country fell into the hands of the nobles, all of whom were seeking their own advancement rather than the good of England.

The king's uncle, Edward Seymour, persuaded the King's Council to make him Lord Protector and to bestow upon him in the King's name the title of Duke of Somerset. Somerset was a Protestant, and the King himself had been brought up a Protestant, so that those who believed in the reformed faith now began to get the upper hand in England.

Fixing a Language

Thomas Cranmer became Archbishop of Canterbury and produced the first edition of the Book of Common Prayer, which with many modifications is still the rule of service for the Church of England. That, together with the English Bible, practically fixed the English language in its present form.

But there were many people in the country, nobles and lesser folk, who wanted the old religion, and when the order was given that the new Prayer Book was to be used in the churches this was much resented.

As the clergyman was going into a church in a Dartmoor village the parishioners declared that they would have "none of the new fashions," but would stick to the old religion of their fathers. Thereupon the priest put on his vestments and read the service in Latin as before, the common people in all the country around, we are told, clapping their hands for joy.

Soon other villages and towns followed the same example, and then, when orders came from London to punish this resistance, a rebellion broke out. There was some hard fighting and Exeter was besieged, but the Government forces eventually won, and after the rebels were defeated their leaders were put to death.

Then another rebellion broke out in the Eastern Counties, not on the grounds of religion, but because some of the great landowners were enclosing the common lands which had always been used by the people.

There were wrongs on both sides, but Bishop Latimer made it quite clear in a sermon which he preached that, though he regarded both parties as covetous, yet the labourers really had a right to the use of the lands.

"The poorest ploughman is in Christ," said he, "equal with the greatest prince that is. Let them therefore have sufficient to maintain them and to find them their necessaries."

He went on to show that they must have sheep and cattle if they were to live and plough, and that pasture was absolutely necessary for the support of these animals. "And pasture they cannot have," he said, "if the land is taken in and enclosed from them."

Roger Ascham, who was tutor to Queen Elizabeth in her girlhood, visits Lady Jane Grey while the members of her family are out hunting, and finds her reading Plato. From the painting by Horsley

Revolt in Norfolk

When commissioners were sent into the Eastern Counties on the pretence of holding an inquiry, they looked so fierce and frowned so threateningly on the poor people that these durst not give evidence or ask for their rights.

Then the rebellion broke out, and the city of Norwich was seized by the rebels. The Government hired German troops to fight them, and at last the rebellion was put down. At least 10,000 men had been killed in the two outbreaks.

Naturally the man at the head of the Government, the Duke of Somerset, came to be greatly hated. Not only did he mismanage affairs at home, but foreign affairs were

also badly conducted, and as he was very ostentatious and lived in great state having amassed a large fortune out of lands taken from the Church, he gave great offence to all sorts of people

His bitterest enemy was Dudley Earl of Warwick and this nobleman plotted against Somerset till at last he felt strong enough to strike He accused the duke of making a disgraceful peace with France and giving up the King of England's rights Somerset was tried for high treason found guilty and soon afterwards beheaded on Tower Hill

Then Dudley became the most powerful man in the realm and persuaded the King to raise him to the title of Duke of Northumberland

The boy King had a second cousin, Lady Jane Grey who was the granddaughter of Henry VIII's sister Mary and it was understood that a marriage was to be arranged between the King and her But Northumberland who was even more ambitious than Somerset had plans of his own He married his son Lord Guildford Dudley to Lady Jane Grey and it was soon quite clear why he had done all this

Lady Jane Grey was perhaps the most beautiful character that the Tudors ever produced It has been said of her that she was adorned with every attribute that is lovely in domestic life, while her piety learning courage, and virtue qualified her to give lustre to a crown

She would have loved a quiet life of study and good works, but it was her misfortune to become the shuttlecock of rival statesmen, and she was tossed hither and thither as policy demanded without any regard for her own rights or wishes

Her parents cared nothing for her except to make use of her for their own advancement and they even took money from Lord Thomas Seymour who paid them to give permission for their daughter to become his ward Seymour a brother of the Lord Protector Somerset wanted power over her in order to make her marry Edward VI It should be explained that wardship gave the power to dispose of a girl in marriage

Now in this matter Lord Thomas Seymour had been acting as the bitter enemy of his brother, the Lord Protector, for Somerset, while in power, had determined to marry his own daughter Lady Jane Seymour to the young King. Somerset therefore had impeached his brother Lord Thomas and had had him beheaded, and, as was always done in the case of traitors at that time his body was divided into four quarters As we have seen, Somerset himself came to the block not very long after

The execution of Seymour put an end to the wardship of little Jane, who now returned to her own parents home at Bradgate, near Leicester Here she was able to do what delighted her, namely to pursue her studies

We are told that the famous tutor of Queen Elizabeth, Roger Ascham, one day paid a visit to Bradgate and

Lady Jane Grey being urged, much against her will, to become Queen From the painting by C R Leslie, R.A.

in passing through the park noticed that the Marquis and Marchioness of Dorset the parents of Lady Jane, and all the ladies and gentlemen of the household were engaged in hunting He could not, however, see little Jane, and when he made inquiries he was told that she was in her own apartment

Two Sorts of Pleasure

He went to the house and asked to see her, and when he was shown into the room he found her reading Plato in Greek, " with as much delight as gentlemen read a merry tale " He expressed his surprise, and asked the girl why she relinquished such pastime as was found going on in the park

Jane replied with a smile, " I wis all their sport in the park is but a shadow to that pleasure I find in Plato Alas, good folk they never felt what true pleasure means "

" And how attained you, madam," asked Ascham, " to this true knowledge of pleasure ? And what did chiefly allure you to it, seeing that few women and not many men have arrived at it ? "

" I will tell you," replied Lady Jane, " and tell you a truth which perchance you will marvel at One of the greatest benefits that ever God gave me is that He sent me, with sharp severe parents, so gentle a schoolmaster '

" When I am in presence of either father or mother, whether I speak, keep silence, sit, stand, or go, eat, drink, be merry or sad, be sewing, playing, dancing, or doing anything else, I must do it, as it were in such weight, measure, and number, even as perfectly as God made the world, or else I am so sharply taunted, so cruelly threatened, yea, presented sometimes with pinches, nips, and bobs and other ways (which I will not name for the honour I bear them), so without measure misordered that I think myself in hell, till the time comes when I must go to Mr Aylmer, who teacheth me so gently, so pleasantly with such fair allurements to learning that I think all the time nothing whiles I am with him And when I am called from him I fall on weeping, because whatever I do else but learning is full of great trouble fear, and whole misliking unto me And thus my book hath been so much my pleasure and bringeth daily to me more pleasure and more, that in respect of it, all other pleasures, in very deed be but trifles and troubles to me "

How sad it is to think of this gentle little girl, who might have been full of good spirits and fun, driven by sheer oppression and cruelty to find her sole pleasure in the study of the classics The " pinches, nips and bobs," not to mention the other punishments which little Jane does not detail, tell a terrible story of her early life We know from other sources that she was beaten by her father when he wanted her to carry out his commands and marry the Duke of Northumberland's son.

John Ulmer, a learned Swiss theologian who was the protégé of her father, writing to Henry Bullinger, the Swiss reformer, at Zurich, says, referring to Jane, " For my own part, I do not think there ever lived anyone more deserving of respect than this young lady, if you regard her family , or more learned, if you consider her age , or more happy, if you consider both."

Ulmer enclosed a letter which Jane herself had written in Greek to Dr.

Bullinger After some references to religion Jane says

"I now come to that part of your letter which contains a commendation of myself, which, as I cannot claim so also I ought not to allow, but whatever the divine Goodness may have bestowed on me, I ascribe wholly to Himself, as the chief and sole Author of anything in me that bears any semblance to what is good and to Whom I entreat you, most accomplished sir, to offer your constant prayers in my behalf that He may so direct me and all my actions that I may not be found unworthy of His great goodness"

An Amazing Child Scholar

It reads more like the letter of a mature scholar than that of a young girl of thirteen

At this time, we are told, she was well versed both in Latin and Greek, and was very desirous of studying Hebrew She corresponded on equal terms with scholars and at least one learned book is believed to have been dedicated to her by a distinguished foreign scholar

She was indeed the wonder of her age, and astonished all those who visited her home Ulmer in another letter says "You will easily understand the extent of the attainments of the Lady Jane by the letter which she wrote to Bullinger In truth I do not think that among all the English nobility for many ages past there has arisen an individual who to the highest excellence of talent and judgment, has united so much diligence and assiduity in the cultivation of every liberal pursuit, for she is not only conversant with the more polite accomplishments, and with ordinary acquirements, but has also so exercised herself in the practice of speaking and arguing with propriety, both in Greek and Latin, that it is incredible how far she has advanced already, and to what perfection she will advance in a few years, for well I know that she will complete what she has begun, unless perhaps she is diverted from her pursuits by some calamity of the times"

These last words were certainly prophetical, but little did Ulmer or Jane realise how sad and tragically they would be fulfilled

In due course poor little Jane was married to Guildford Dudley She did not want to marry him, but her father, who had now been made Duke of Suffolk, was insistent, and we are told that her reluctant submission to the marriage was extorted by the urgency of her mother and the violence of her father, who compelled her to accede to his commands by blows

Merely a Pawn in the Game

Poor little Jane, she was both learned and beautiful but she was short and so she was made to wear chopines or cork shoes about four inches in height to give her a more majestic appearance She was led to the altar and now a new terror was added to her life for she dreaded her father in law and abhorred his wife Yet she was condemned to go and live with them at their home on the Thames Sion House

The Duchess of Northumberland had promised at the wedding that the poor child should be allowed to remain with her mother but when Jane asked for this promise to be fulfilled the Duchess was furious and insisted that she should stay at Sion

The explanation was quite simple Henry VIII and his Parliament had disinherited the Princesses Mary and Elizabeth, and Northumberland had persuaded the young King whose health was so bad that it was clear that he could not live long, to make Jane his heir

The Duke's idea in marrying his son to Jane was that he should really become the ruler of the kingdom Indeed after Edward died despatches to foreign ambassadors referred to Guildford Dudley as though he were actually king and not merely a consort

Poor little Jane was always being dragged about from place to place in pursuance of the policy of her relatives Even when she was ill she was made to ride on horseback, and now, although her health was bad, she was rowed up and down the river between Chelsea and Sion House

One day she was suddenly summoned to Sion, a two hours' journey on the river

"When we arrived at Sion," she says "I found no person there But thither came directly afterwards the Marquis of Northampton, the Earls of Arundel, Huntingdon, and Pembroke, who began to make deferential speeches bending the knee before me, and their example was followed by several noble ladies causing my cheeks to be suffused with blushes My distress was further increased when my mother and my mother-in-law, the Duchess of Northumberland entered and performed to me the same homage Then came Northumberland himself, and as President of the Council declared to me the death of the King"

The Cat out of the Bag

The cat was out of the bag, and the Lady Jane was told that she was Queen of England She tells us that she was stunned at the news and fell to the ground weeping piteously and dolefully lamenting her own insufficiency and the death of the King

"I swooned indeed and lay as dead but when brought to myself I raised myself on my knees and prayed to God that if to succeed to the throne was indeed my duty and my right He would aid me to govern the realm to His glory"

She was taken off to the Tower just as though she were a prisoner which indeed she was and all the trappings of royalty were given to her She was proclaimed as Queen by the heralds, but the public were not enthusiastic, and a potboy for expressing disgust, had his ears cut off and was placed in the pillory

The Crown Jewels were presented to Jane and she was told that her husband would be given the title of King To this she would not agree, although she promised to make him a duke

Her husband and his parents were furiously angry, and Jane tells us that she was "maltreated by my husband and his mother" No wonder she became very ill, and believed that she was being poisoned by the Duchess of Northumberland But, of course, that was not the case for the Dudley family had every interest in keeping Jane alive

There is no doubt that Northumberland's idea was that his son should really become King Guildford I of England

The arrest of Lady Jane Grey. From the painting by Deveria

and Ireland and that his son's wife Jane should be very subordinate The people of England however thought differently

A placard was placed on a pump in London stating that the Princess Mary had been proclaimed queen in every town and city in England London alone excepted and this was largely true The Dudleys had not been quick enough and Mary had escaped to Framlingham Castle in Suffolk, the strongest fortress in the Eastern Counties and there a formidable army gathered round her

The End of a Nine Days' Reign

Northumberland and his friends tried to raise an army but failed and soon the whole opposition to Mary collapsed Those who had placed Jane on the throne now deserted her and tried to make their peace with the dominant party Even her father and mother forsook her and sided with Mary her father himself proclaiming Mary as queen at the Tower gates Then he went to his daughter and told her she was no longer queen and must lay aside that dignity

Sir replied Jane I better brook this message than my advancement to royalty Out of obedience to you and my mother I have grievously sinned and offered violence to myself Now do I willingly and obeying the motions of my own soul relinquish the crown and endeavour to solve those faults committed by other if at least so great faults can be solved by a willing and ingenuous acknowledgment of them

Poor Jane's nine days reign was over She was now indeed a prisoner, together with her husband and father in law and all her property was seized But while many of the plotters were forgiven no one pleaded for poor Jane

However, neither she nor her husband was executed when Northumberland lost his head for treason He was more despicable in death than in life for he even changed his religion at the last moment in a vain effort to save his neck

A month or two later Lady Jane Grey and her husband were tried for high treason at the Guildhall in London and sentence of death was passed on them But they were not executed

Mary's harsh rule had meanwhile turned many of the public against her and a rebellion led by Sir Thomas Wyatt broke out in which Jane's father took part The rebellion was put down but the Queen now felt that the time for mercy was past and so Jane and her husband were ordered to the block together with her father

The Watch from the Window

Lord Guildford Dudley had asked that he might bid his wife a final farewell and permission was granted but Jane declined feeling that the interview would unnerve them both She however watched her husband pass to execution from a window of her apartment

Then afterwards she was led forth by the Lieutenant of the Tower to a scaffold specially erected for her on Tower Green She ascended the stairs with a firm and lively step and then addressing the people declared that she was perfectly innocent before God of any desire to make herself queen Kneeling down she repeated a psalm then giving her handkerchief and gloves to her weeping ladies and her book of prayers to the brother of the Lieutenant of the Tower she began to loose her garment at the neck Her ladies helped her and then she bound a fair handkerchief round her eyes

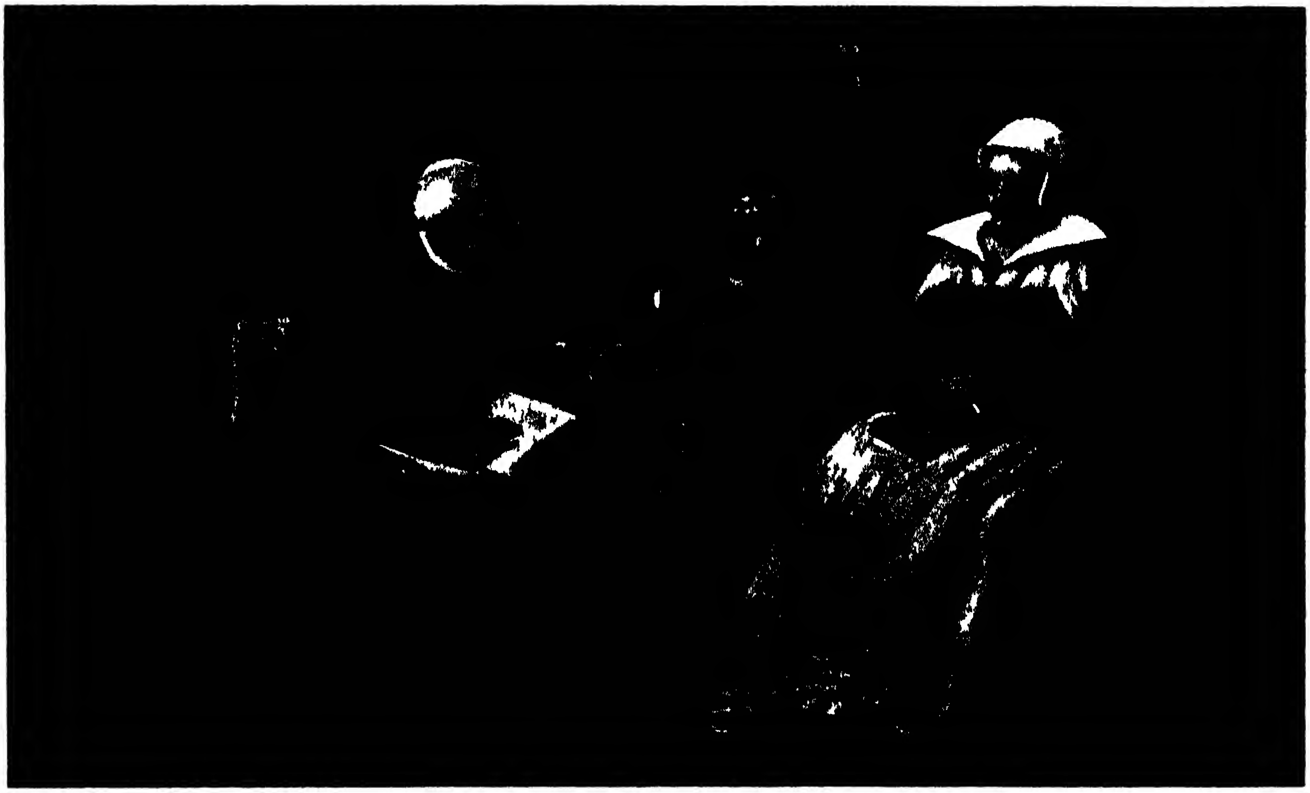
Forgiveness for the Headsman

The executioner knelt and asked her forgiveness to which she replied Most willingly I pray you despatch me quickly she added Then feeling for the block she placed her neck thereon the axe fell and poor little Jane's head was severed from her body

Sir Aubrey de Vere in his play Lady Jane Grey makes her say as her last words

> My sentence hath been just! not for aspiring
> Unto the crown but that with guilty weakness
> When proffered I refused it not From me
> Let future times be warned that good intent
> Excuseth not misdeeds

It is the saddest and most tragic story in English history



Lady Jane Grey in the Tower of London after her arrest From the painting by W F Yeames, R A

WONDERS OF LAND & WATER

THE WONDER OF THE GENTLE DEW

We read a great deal about the dew in the works of the poets and also in the English Bible. This is a proof not only of its beauty, which has seized the imagination of the poets, but also of its importance. The scientific study of the dew, however, is just as fascinating as its poetic description, and here we read much that will interest us about the dew and how it is formed

Most of us realise that there is always a much heavier dew after a cloudless night than after a night in which the sky has been covered by a canopy of clouds. The reason for this is that the covering of clouds acts as a blanket.

A blanket is not warm in itself. If on a chilly night we cover ourselves with a blanket, this does not warm us in the same way as a hot water bottle does. It merely prevents the heat of our body from escaping, the woollen blanket being a bad conductor of heat.

In the same way the covering of clouds prevents the heat which the earth has received from the Sun during the day from escaping into the air, or as scientists put it, prevents the earth from radiating its heat.

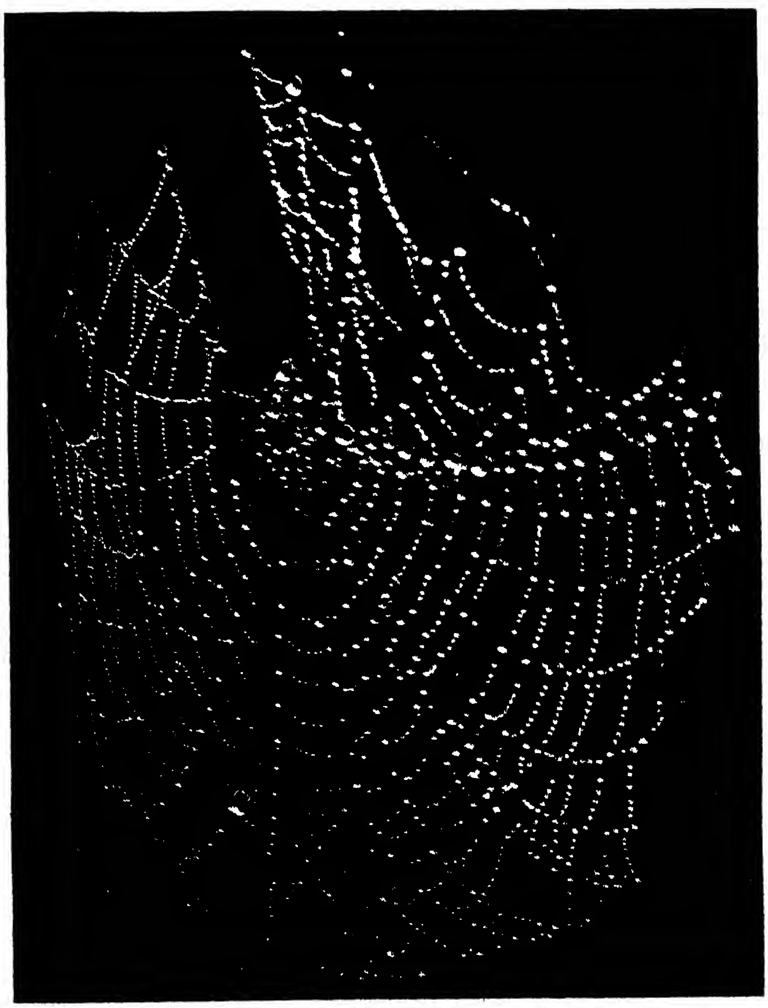
What Dew Is

Dew, as we read on Page 339 is the condensation of water vapour from the air upon the surface of leaves and other solid bodies. During a warm day evaporation takes place from the rivers, ponds and other sources and the air contains a great deal of water vapour. On a clear night the leaves and ground give up much of the heat they have absorbed and become colder than the air. At once the air which is in contact with them becomes cool, and as cool air can hold less water vapour than warm air, it gives up some of its moisture which is condensed into drops of water upon the leaves, blades of grass, cold ground, and so on.

But as we read on Page 339, all the dew does not come from moisture that was actually in the air. Some of the water vapour which condenses as dew, rises from the ground. The earth, to some depth beneath the surface in a climate like that of England, is always more or less moist, and this moisture evaporates, passing up into the air. The warmer the earth the more rapid will be the evaporation of its moisture into the air and if the air is warm and is not yet saturated with water vapour and the surface of the ground itself is also warm, then the moisture continues in the vapour form. But at night, if the earth, blades of grass and other solid surfaces radiate their heat and become cooler than the air around, dew forms.

The origin of the dew is thus clear: some of it is condensed from moisture already in the air and some of it is condensed from moisture rising into the air from the damp ground. If the earth beneath the surface is cold, then evaporation takes place slowly and dew is less abundant.

The grass and leaves and surface of the ground must cool down to a far lower temperature than the air immediately in contact with them before dew can be formed. Dew point is the temperature at which dew forms, and of course it varies at different times. If the air containing the water vapour is very warm, then the solid objects need not be very cold for the condensation of moisture. If on the other hand the air is cool then the solid objects must be much colder before dew is formed. When dew point is lower than 32 degrees Fahrenheit, then the dewdrops freeze and become hoar frost.



A dew-laden spider's web photographed on an autumn morning. Its likeness to a diamond necklace as the Sun shines upon the glistening droplets can be seen even in a photograph

Autumn Dews

Dew is most likely to form when the ground beneath the surface is warm, but the surface itself is cold. That is why our heaviest dews occur in autumn. At that season the Sun's rays are hot during the daytime but the nights are getting long and if the sky be clear, the ground and grass radiate a great deal of their heat.

In spring, although the Sun may be warm, the ground beneath the surface is still cold from the winter, and so does not give up so much of its moisture as it does in autumn.

Of course, a condition necessary for the formation of dew is that there should be no wind, or at any rate very little. If there is much of a breeze the

air containing the moisture is blown away from the cold surfaces of leaves, grass and ground before it has a chance of giving up much of its water vapour. It does not get a chance of being in contact long enough with the grass or ground to be cooled down to dew-point. The only exception is when the whole of the air is very near the temperature of dew-point and does not need much more cooling down to deposit drops of water.

It is interesting to remember that the Spanish name for dew is sereno, which comes from the Latin word serenus, meaning calm or placid, the kind of condition in which dew is formed. A serenade is music played out of doors at the time the dew is forming.

The formation of dew is well illustrated by the experiment of bringing a bottle of cold water into a warm room where a number of people are breathing. This is described on Page 396. Moisture also forms on our spectacles when we go into a warm crowded room out of the cold on a winter day. In the same way is dew is formed at night.

The dew, as we know, forms in drops, and a dew-clad leaf or blade of grass shining in the morning Sun appears spangled with diamonds or pearls. A spider's web covered with dew has, when played upon by the Sun rays, the appearance of a beautiful diamond or pearl necklace. The poet has described the beauty of the morning:

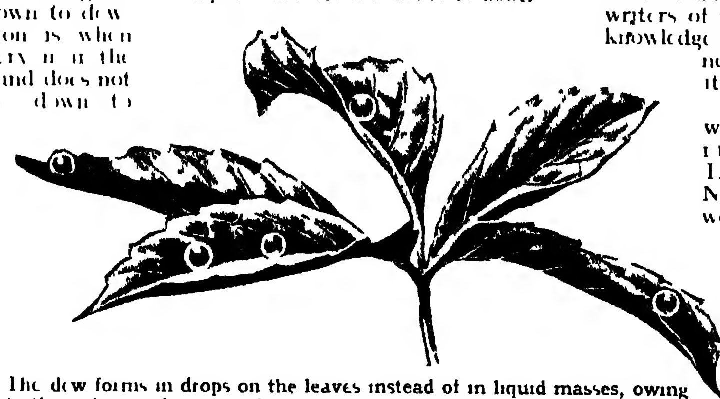
When [illegible] pearly diadem
Was hung upon [illegible] stem
And the [illegible] shell was set
With [illegible] bright dewy coronet

Why does the dew always appear as little spheres of water? We should naturally suppose that as the dew formed the water would spread itself out into liquid masses over the whole surface of the leaf or ground under the action of gravitation. But it does not do so; it forms in globules. The reason is that the cohesion between the molecules of the water is greater than the action of gravitation.

The same thing is found when mercury or quicksilver is dropped on a solid surface such as that of a tablecloth. The mercury forms into little globules and does not run together easily, as we might expect. It does not, however, take very much to overcome this cohesion of the molecules. If we push the drops of mercury together they will form a mass, and if we draw our finger across a dew-covered leaf the dewdrops will then run together and form a continuous stream of water.

Most of the poets find inspiration in the dewdrops. Milton speaks of the

Dew-drops, which the Sun
Impearls on every leaf and every flower.



The dew forms in drops on the leaves instead of in liquid masses, owing to the cohesion between the molecules of water. This is greater than the action of gravitation which would make the fluid run together.

and Longfellow, in the Song of Hiawatha, is scientifically correct when he writes:

Calm, as silent as the dew comes,
From the empty air appearing,
Into empty air returning,
Taking shape when earth it touches,
But invisible to all men
In its coming and its going.

When mercury or quicksilver is dropped upon a flat surface like a tablecloth it forms into little spheres as does the dew, instead of running together as a mass. The cohesion between the molecules, as in the case of the dew, overcomes the action of gravitation which would cause it to run together as it falls from the bottle.

In dry weather dew is of very great importance to vegetation. There are many references in our English Bible to the dew, which shows that the translators of the Authorised Version were quite alive to its importance. But when we read in the Book of Proverbs (III. 20) that "the clouds drop down the dew," and in Isaiah (XVIII. 4) of "a cloud of dew in the heat of harvest," we might think the writers of these books had very little knowledge of the dew. The dew does not come as a cloud nor does it drop from the clouds.

But those early Bible writers were not at all ignorant of the facts of Nature. They were among the keenest Nature students that the world has ever seen. They knew the whole story of evaporation and condensation and rainfall, for one of them wrote: "All the rivers run into the sea; yet the sea is not full; unto the place from whence the rivers come, thither they return again." (Ecclesiastes I. 7.)

So in their references to what is described by our English translators as "dew" they were perfectly correct. The Hebrew word translated "dew" really means "night mist."

In Palestine from May to October the Sun shines with great heat during the day, and everything is extremely dry, so that vegetation becomes parched and would perish altogether but for a wonderful natural provision.

Mist from the Wind

At the end of August and during September and October the prevalent westerly winds take up an immense quantity of moisture from the Mediterranean Sea as they pass over it. Then as they blow across Palestine the moisture with which they are charged becomes condensed when it meets the cold air over the land, and clouds of mist are at once formed, something like the lightest form of Scotch mist, and this condenses upon the vegetation and the ground, giving much needed refreshment to the plants.

It is this night mist to which the writers of the Bible refer when they speak of "dew," according to our English translation. The moisture deposited by this mist is much greater than any dew could provide. We can understand Gideon being able to wring a whole bowlful of water out of his "dewy" fleece as the result of one night's exposure.

Of course dew is deposited in Palestine as in other countries by the cooling of the surface of the ground on cloudless nights, but this takes place in winter, which is the period of the year when much rain falls in the country, and so the dew is practically valueless there.

A WONDERFUL PHOTOGRAPH OF THE MORNING DEW

This magnificent photograph by Monsieur Emmanuel Sougez shows the formation of dew on the leaves of a cabbage. As can be seen, the dew is formed in drops, but as these run together they tend to unite and form little masses of water, under the action of gravitation, which overcomes the cohesion of their molecules. The dewdrops are formed by the condensation of the invisible water vapour contained in the air. As the air cools it is able to hold less moisture and so some of this becomes condensed on cold surfaces like those of leaves. But streets and buildings radiate only slowly the heat they have acquired during the day, and dew rarely forms on them

GIANT WALLS OF ROCK BUILT UP BY FIRE

Lava does not always pour out from the crater of a volcano Sometimes it comes out through long fissures When it emerges in this way the out-flow is called a fissure eruption Many great fissure eruptions have taken place in earlier ages of the world's history, and even in recent times they have been known in Iceland The lava fills up the fissure or crack and is called a dike Then, in the course of ages, the surrounding softer rock is worn away by wind and weather, and a wall of lava is left Here we see a remarkable dike formation, known as the Devil's Slide, in the State of Utah It consists of two parallel dikes about thirty feet apart, and ascending the Weber Canyon for over 1,500 feet These dikes are several hundred feet high. Much of the sandstone rock through which the lava was poured when in its molten state, has been worn away by erosion, hence the height of the dike-walls

WHAT HAPPENS WHEN THE FIRE BURNS

We all like to watch the fire as it burns in the grate. But do we ever ask ourselves what is happening? Why does the coal burn and how does it burn? The moment we put a shovelful of coals on a burning fire wonderful changes begin to take place, and on this page we read something about the transformation that occurs, turning black coal into a warm and cheerful blaze

What happens when the fire burns in the grate? We know that to light a fire we must first raise the paper to its ignition point, that is the point at which it bursts into flame, that the heat from the paper will raise the wood to ignition point, and when that burns its heat raises the coal to ignition point, so that that, too, will burn and flame.

But when the fire is once alight and the coal is burning brightly, what is really going on in the grate? Of course the domestic fire, like all fires, is an example of combustion, and combustion is a combination of oxygen with other elements to form new substances.

The coal which we put on the fire is composed mostly of carbon, and so the combustion in the grate consists of a combination of oxygen with the carbon. The oxygen is obtained from the air which enters the grate through the bars or openings at the bottom, and each atom of carbon in the coal, under the influence of heat, combines with two atoms of oxygen and form carbon dioxide gas.

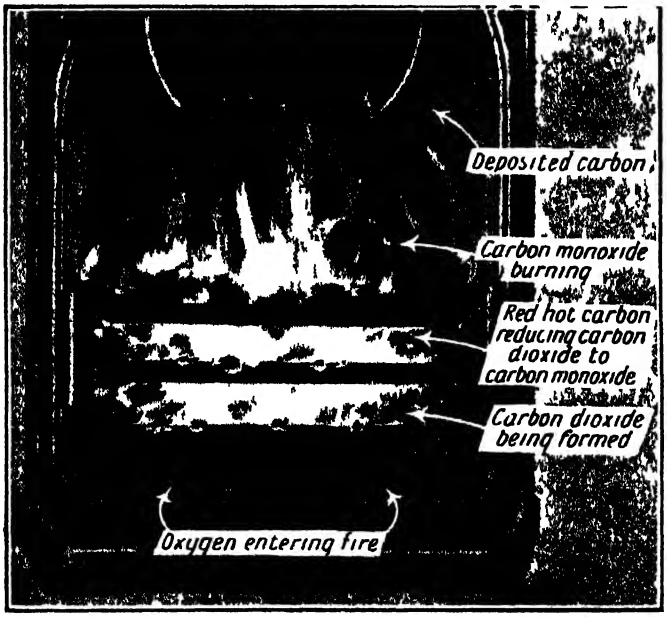
As this passes upward over the red-hot cinders, which are really red-hot carbon, one atom of the oxygen in each molecule of carbon dioxide flies off and unites with a single atom of carbon. In this way the carbon dioxide gas is changed into carbon monoxide, the molecule of which contains not three atoms but two, one of carbon and one of oxygen.

This gas, unlike carbon dioxide, is inflammable, and as it passes through the upper part of the fire it catches light and burns with a bluish flame, producing much heat. A certain amount of the carbon of coal does not get burnt, and is deposited as soot inside the chimney, or escapes in fine particles which we call smoke through the chimney-pot.

It used to be thought that this was what happened always when coke or coal was burnt in air, but it has since been discovered that when coke is the fuel and it is burnt in dry air, at a great heat, the carbon monoxide gas is formed first, and that the carbon dioxide with two atoms of oxygen in every molecule is formed later by each molecule of the simpler gas taking up one more atom of oxygen.

The very latest researches suggest that even before the carbon monoxide gas is formed from the carbon of the coke and the oxygen of the dry air other changes which are not yet fully understood have taken place.

It is believed that the carbon when it has been raised to a very high temperature, something like 950 degrees Centigrade, and then cools down, absorbs a certain amount of oxygen without actually combining with it, or at any rate combining very loosely. This absorption is called by scientists occlusion, a word which means shutting up. Then from this is formed the carbon monoxide gas which later produces carbon dioxide.



This picture shows what is going on in the grate when the fire is burning brightly

This may all sound a little technical, and we may wonder how it is that heat produces these changes in the fuel.

Before we can understand that we must first grasp what heat really is. Up to nearly the beginning of last century, scientists believed that heat was an invisible fluid which was hidden away in all substances, and that a hot body contained more of it than a cold one. This theory during the nineteenth century, was proved to be wrong, and now we know that heat is really a form of energy or activity.

All matter is made up of tiny particles known as molecules. They are too small to be seen even with the most powerful microscope, but if we could greatly increase the power of the microscope so that it would reveal the molecules when we looked at any substance, such as coal or iron, we should see that it was made up of an inconceivable number of tiny particles like grain. These particles or molecules, as we know, are themselves made up of atoms, which again are made up of smaller particles known as protons and electrons. We read about these on Pages 145 to 148.

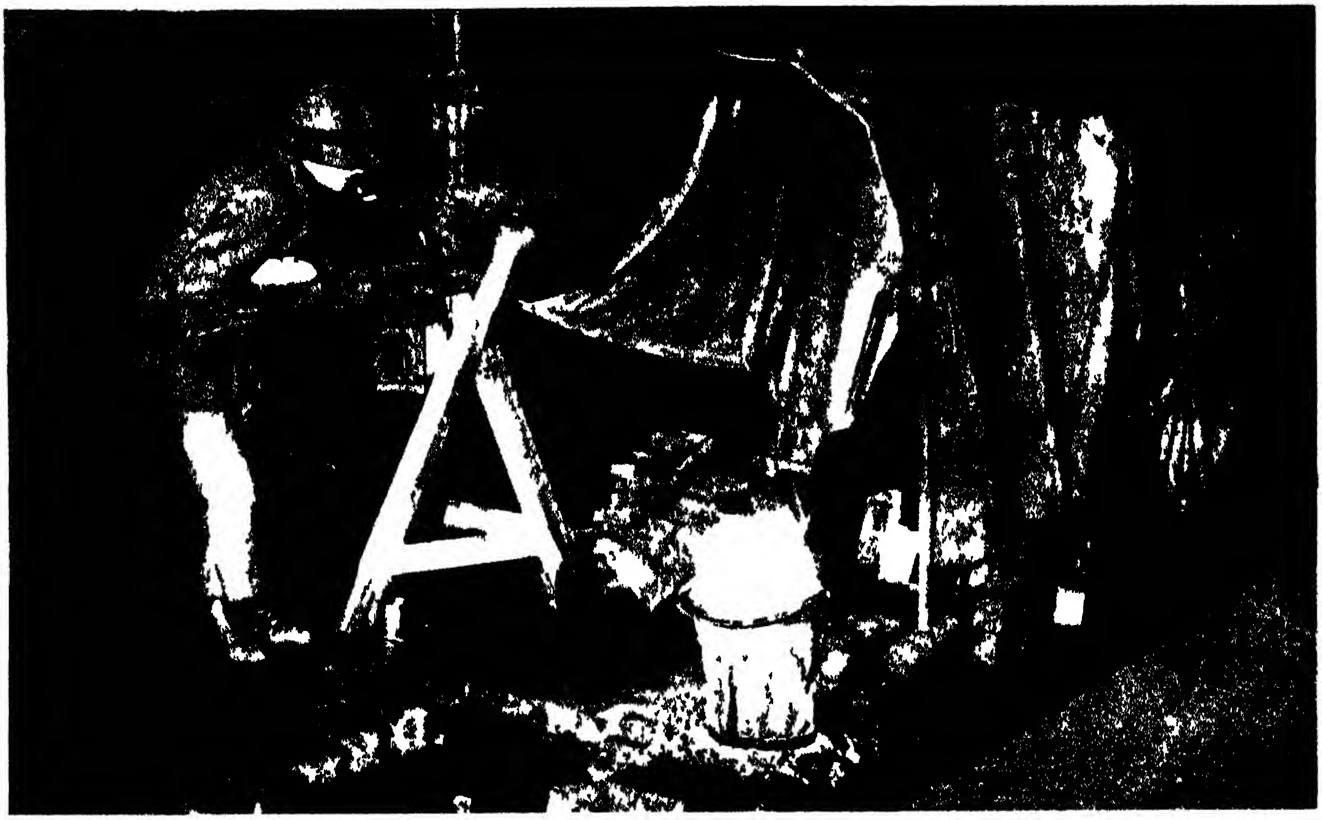
But the molecules even of a piece of coal or iron are not still. The piece of iron itself as we look at it may be perfectly still, resting on the ground or a table. But the molecules are in perpetual motion to and fro, just as the balance wheel of a watch is constantly moving to and fro.

Now when heat is applied to any substance this has a tendency to make the molecules move more rapidly, and the hotter the substance gets the faster the molecules move. At last there comes a point when the molecules in their movement separate from one another and the substance becomes broken up. We see this in the fire of the domestic grate, and we see it in the bending and twisting of girders when a great building is destroyed by fire, and when lead is melted and becomes a liquid.

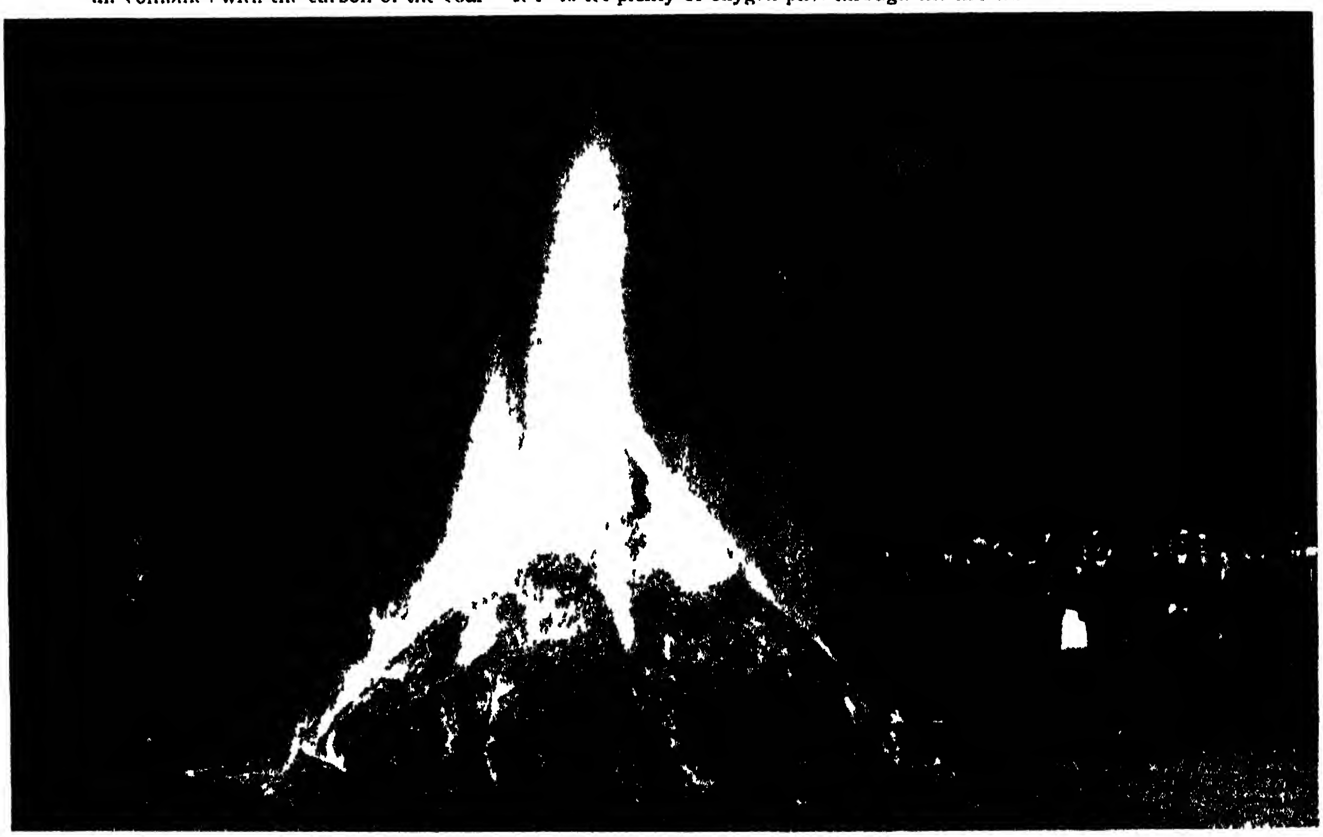
The heat has overcome the cohesion or attraction of the molecules so that they do not hold so tightly together. If our eyes could become like enormously powerful microscopes when we look at the burning coal in the grate we should see the truly wonderful sight of its surface composed of myriads of moving molecules with the atoms rushing off with atoms of oxygen from the air.

We are so familiar with the common things of life, such as the fire in the grate, the light in a gas jet, and so on, that we little realise the wonder and romance that are wrapped up in them.

WHY THE FIRE PAIL MUST HAVE HOLES



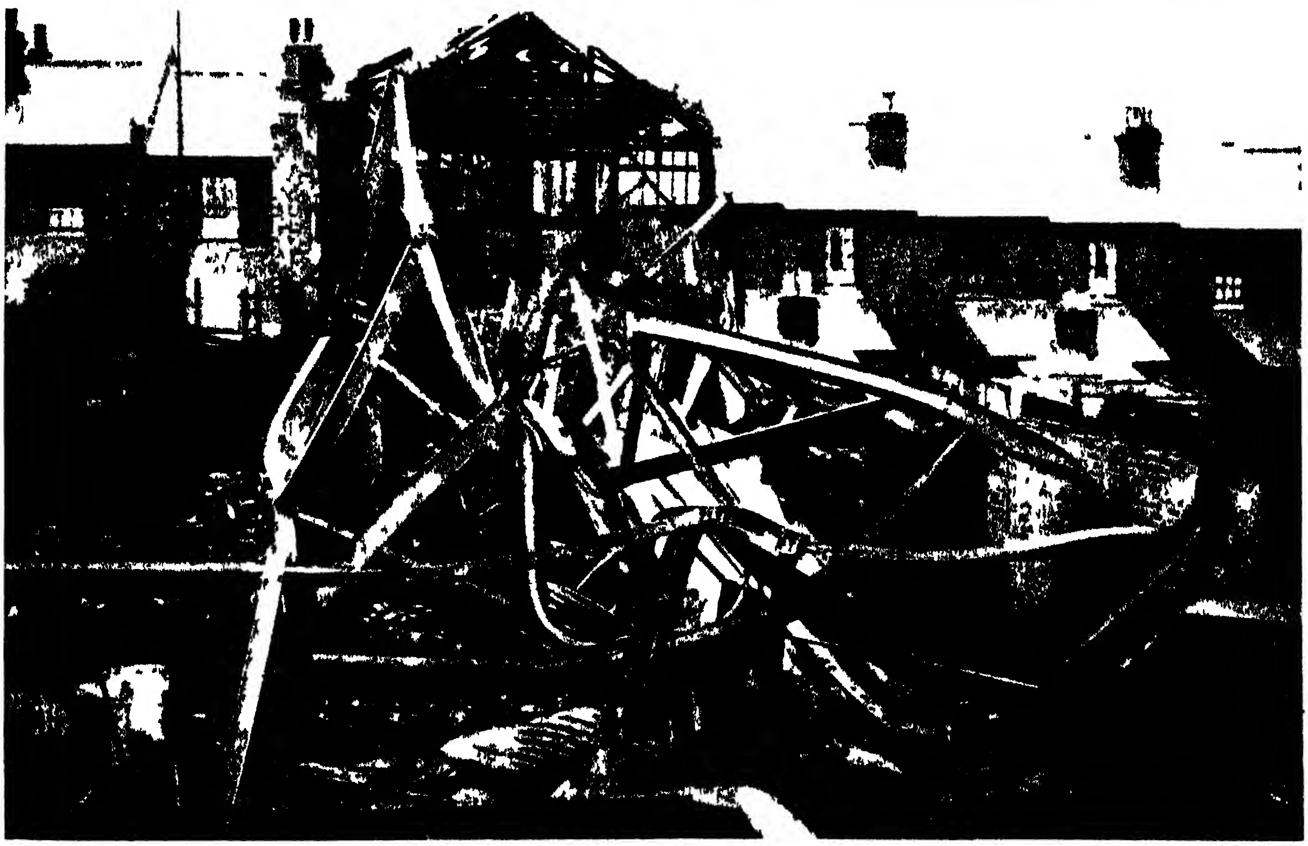
We must have noticed that the pail in which a night watchman lights his fire is always perforated There is a good reason for this If there were no holes in the pail the fire would not burn brightly When a fire burns combustion goes on that is, oxygen from the air combines with the carbon of the coal It is to let plenty of oxygen pass through the fire that the holes are made



A bonfire, if it is to be successful must have its material packed lightly together If the fuel is all pressed closely the fire will not burn, but will merely smoulder, or possibly go out because for rapid combustion large supplies of oxygen are required to combine with the carbon of the fuel By packing the material loosely plenty of air can get in and pass through the bonfire, thus helping combustion

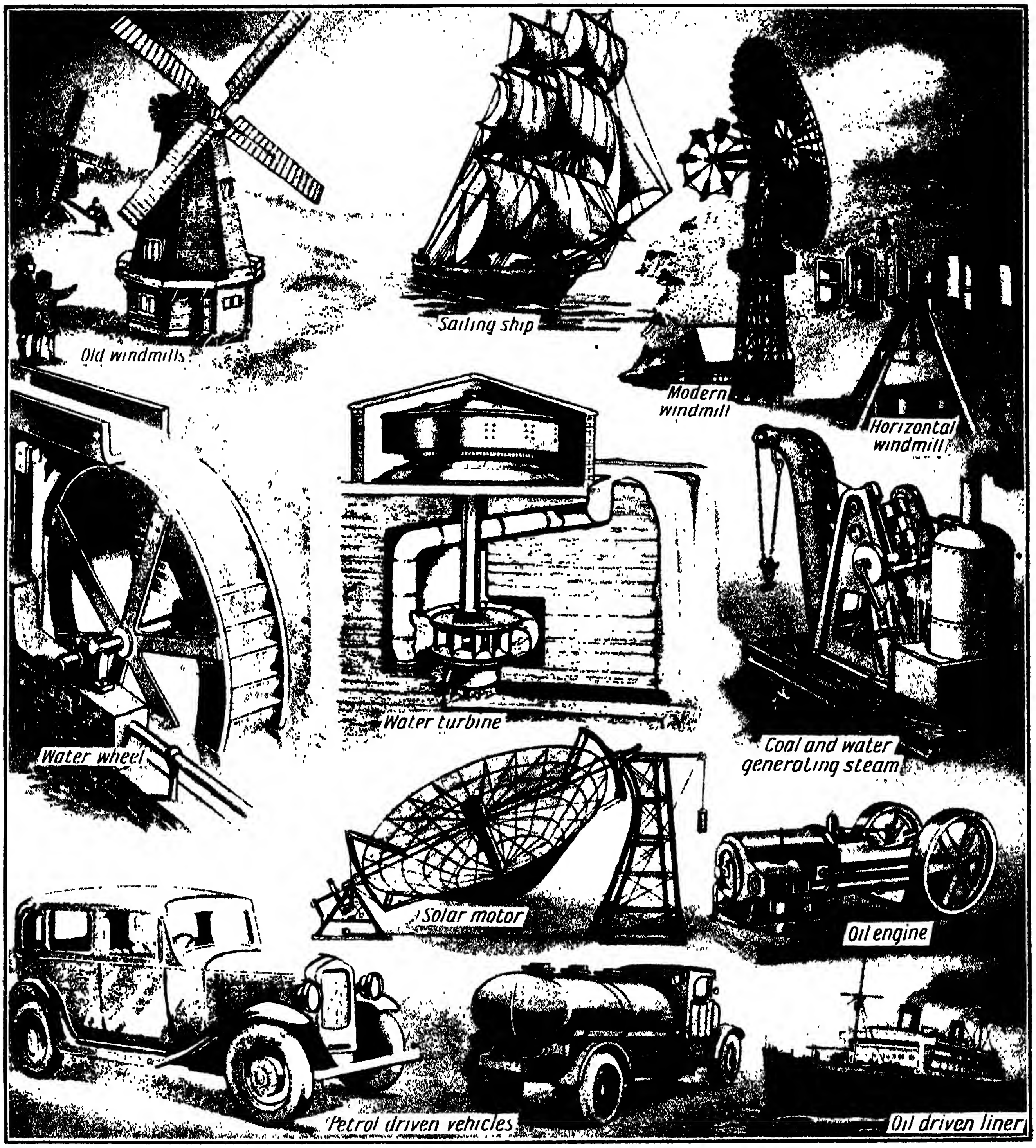
PROOF THAT HEAT IS A FORM OF ENERGY

The tremendous energy of intense heat is clearly proved by the damage a fire does when a building is well alight. Even with all the power and appliances of a modern fire brigade it is very difficult to overcome a fire after it has once got a good hold of a building. This picture, for example, shows how a large part of a town in Massachusetts was destroyed in a few hours with damage amounting to over £400,000. Think of the amount of energy that would have had to be expended if the buildings had been removed by man's labour instead of by fire. Fire, too, when out of control, works far more rapidly than the fastest machinery man can make.



Here is another example of the energy of heat. The photograph was taken after a fire had gutted a timber works in a London suburb. More than a hundred firemen with all their best appliances were engaged for a long time in trying to extinguish the flames but, as can be seen, the premises were completely destroyed and all that could be done was to prevent the fire from spreading. The massive iron girders which supported the building were twisted and bent into a variety of shapes. What a vast amount of energy would have been needed in a workshop to twist these in this way. It is by harnessing heat that the machine-builder achieves his triumphs.

HOW MAN USES THE POWERS OF NATURE



Energy cannot be created, but it can be obtained from various sources in which it has been stored up by nature. Sometimes, as in the case of coal and oil, the storage has lasted through millions of years. At other times the energy has been stored for only a short time as in the case of the wind that drives the windmill. The earliest of all natural powers to be used by man were the wind and water. The wind drives the windmill whether it be of the old-fashioned type or the modern form, and it has also long been used to drive ships across the sea Water power, wherever falling water could be obtained, has been used from early ages, and we find it in the old-fashioned water-wheel of the mill, or in the more modern turbine, such as is found at the Niagara Power Station and elsewhere. Both these natural sources of power, wind and water, are used directly, and supply mechanical energy without any intermediate stage of transformation. The sun's heat is also used directly in a few places where it is concentrated by mirrors or polished metal surfaces upon a vessel containing water. The water boils, steam is generated, and some form of machinery is driven. The solar motor shown here, has been in use for many years in California. The more important sources of energy, however, which have been utilised by the engineer, are not used directly but are subjected to chemical changes which produce heat energy, and this is transformed into mechanical energy by some form of engine. The two great natural sources of power of this kind are coal, which is burned to change water into steam, the steam being used to drive an engine, and the engine working machinery ; and oil, which is burned either in its crude state, as in the Diesel engine or in a refined state, as in the petrol engine of the motor-car. Here we see various sources of natural power utilised by man

MARVELS of MACHINERY

HOW AIR IS MADE TO CUT THE HARDEST ROCK

CUTTING rock or breaking up concrete with chisels and sledgehammers is very slow and hard work, but that is how it had to be done until 1856, when an English engineer hit on the idea of using air to do the job. The pneumatic drill is simply a chisel hit by blasts of air instead of by a sledgehammer.

If air is forced or compressed into a small space it struggles to get out, as we see in the article on the jet engine in page 248 of this book. With a pneumatic drill, the compressed air does not flow in a continuous stream but is controlled to escape only in short spurts.

Air for a pneumatic drill is compressed by a motor-driven pump which draws air from the atmosphere and forces it into a cylinder at a pressure of hundreds of pounds to the square inch. From the compressor tank a strong hose leads to the handle of the drill and enters at the inlet valve (marked IV in the diagram on the right).

On the handle of the drill there is a throttle (T in the diagram) which controls the intake of the air through the valve. When the throttle is raised no air enters the valve, but when it is pressed down by the operator squeezing the handle the valve opens and compressed air flows through.

From the inlet valve the air passes to another valve (EV) which admits air alternately above and below a piston D. When the compressed air is admitted above the piston the piston is forced down and strikes against a circular piece of hardened steel called the anvil block (A). The anvil block in turn strikes against the face of the steel chisel (S) which is held in place by a catch (R).

When the air passes under the piston the air is forced back and the valve admitting the air closes. At the same time, the piston uncovers the exhaust port (E) and relieves the pressure from the back of the slide valve, which returns ready for another down stroke. At O there is a small reservoir of oil which is fed through a tube to lubricate the mechanism of the drill.

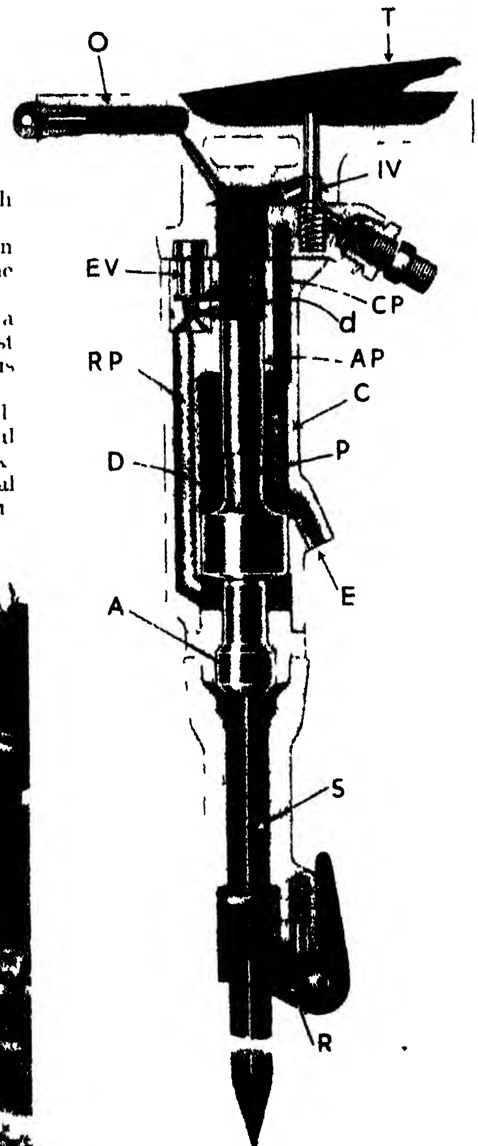
In the latest type of pneumatic drill the piston strikes the top of the drill 2,000 times every minute, and one drill can do in a single day as much work as 20 men with hammers and chisels.

Pneumatic drills are also used in quarries for the drilling of holes for the insertion of explosive charges. In these drills water is led down a groove in the chisel to lay the dust which otherwise would be dangerous to the operator.

Another type of pneumatic drill specially designed for use in coal mines has instead of a chisel a corkscrew bit which bores into the coal in much the same way that a carpenter bores round holes in wood.

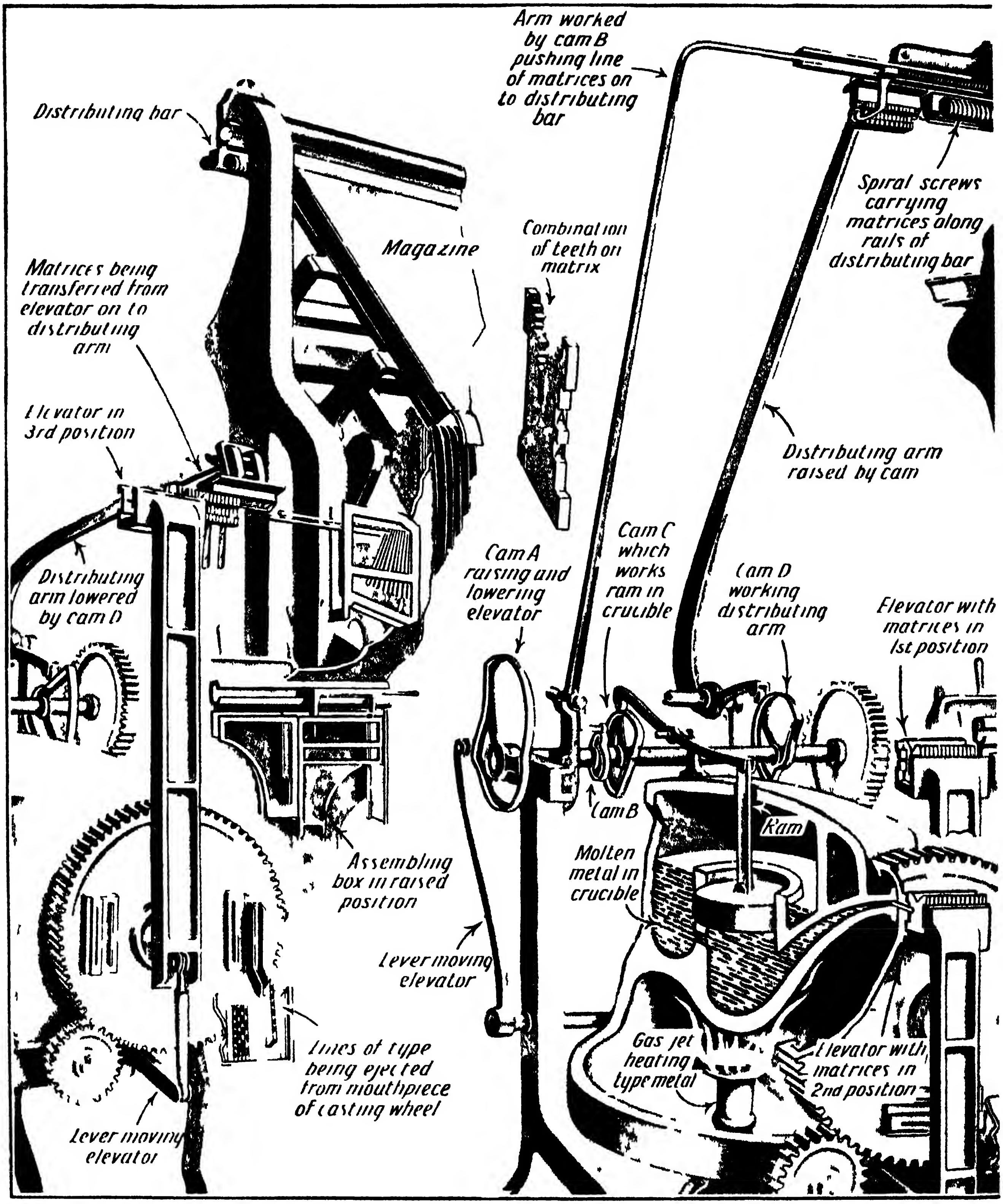
In the boring drill, compressed air enters a throttle valve in the handle and then passes to another valve which controls the movement of the piston. On its forward and downward movement the piston strikes against the top of the drill, forcing it into the coal. When the piston returns it slides over a fluted bar which turns the piston and the chisel.

To blow out the cuttings and dust a proportion of the compressed air entering the drill passes through the piston and the drill to the cutting face.



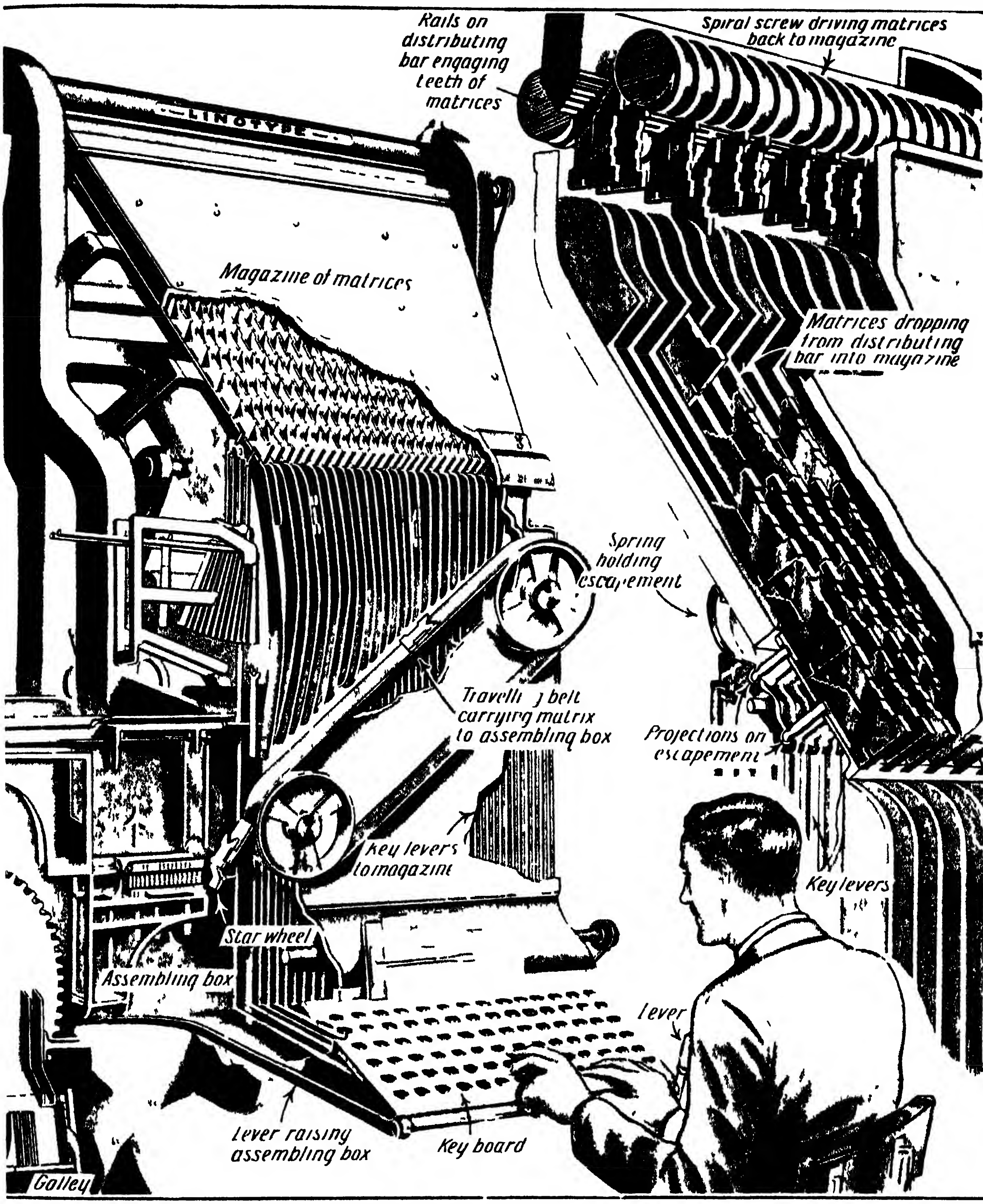
Once upon a time breaking up a road was slow and hard work and needed large gangs of navvies with picks, chisels and sledgehammers. Now the work can be done many times more quickly and with much less labour by using pneumatic drills, as in the above picture of men tearing up the concrete foundations of a street. On the right is the inside of a pneumatic drill made by Ingersol Rand. C is the drill casing; P, the piston head; RP, AP, CP and D are air paths. The rest of the lettering is explained in the text.

HOW THE WONDERFUL LINOTYPE MACHINE



The type for a newspaper is not set up by hand but by a marvellous machine known as the Linotype because it makes a whole line of type at a time and the picture shows how it works The operator sits at a keyboard and taps out the letters as fast as he can The machine picks out the letters sends them to a crucible where it casts them line by line returns the matrices or metal plates bearing the original letters to their place in the magazine at the top of the machine and passes on the cast lines of type and sets them in their right positions on a metal tray The picture shows how when the operator touches a key a lever is moved which releases the required matrix and drops it on a travelling belt which carries it to an assembling box As soon as this assembling box is full of matrices that is as soon as a line of type is set up the operator pulls over a lever on his right and this by a series of connecting levers pushes up the assembling box The line of matrices is caught by two little fingers which driven by a spring push the line to the left along two rails and deposit the matrices in an elevator This elevator is moved up and down by a lever worked by a curiously shaped cam marked A As soon as the matrices are in the elevator the cam is moved round the operating levers and the elevator drops to position No 2 The line of matrices on the elevator is now in direct connection with a mouthpiece on the other side of which is a pot of molten metal At this moment another irregular cam marked C as it revolves forces down a ram in the crucible and drives sufficient molten metal through the mouthpiece against the line of indented letters on the matrices casting a row of letters in one solid piece which is really a complete line of

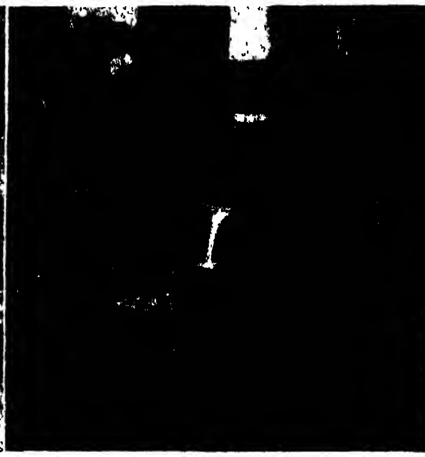
SETS UP THE WORDS FOR YOUR NEWSPAPER



type This metal solidifies almost instantly Directly the line is cast the elevator rises to the highest position shown in the left-hand drawing At the same time the ram rises from the crucible so that the metal ceases to flow From the third position of the elevator shown in the picture, the line of matrices is pushed on to a rail by a claw worked by a spring The matrices are then suspended from the rail This rail is attached to the distributing arm worked by cam D At once the arm rises and carries the matrices up to a distributing bar where a claw worked by a spring and attached to a distributing arm, pushes the matrices on to a distributing bar The distributing arm is worked by the small triangular cam B As soon as they reach the distributing bar the matrices engage with the spiral grooves of two revolving screws, one on each side, and these work the matrices along the rail The matrix of each letter has a different combination of teeth at the top As the matrices are driven along the rail they come to places where the lines on the distributing bar are broken and each matrix is dropped into its proper place ready for use once more While the matrices are being carried back to the magazine, a wheel known as the casting wheel has carried round the line of cast type and dropped it into a tray, where line after line is placed in position The right-hand picture shows in detail the return of the matrix to the magazine and at the bottom we see how only one matrix is released at a time by means of an escapement When the operator presses one of the keys on the keyboard a lever is raised, causing a projection to move and release the matrix At the same time a second projection comes up to prevent the next matrix from falling

HOW A BIG BELL IS MADE AND TUNED

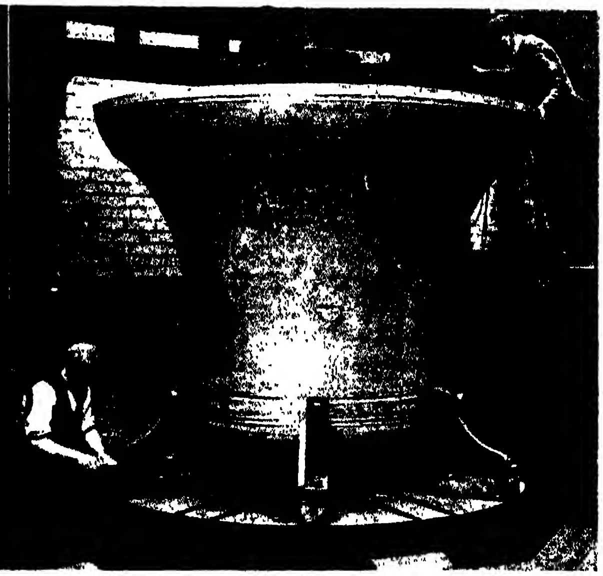
The first step in making a bell is to shape a core and a cope to fit over it. The space between forms a mould for the metal



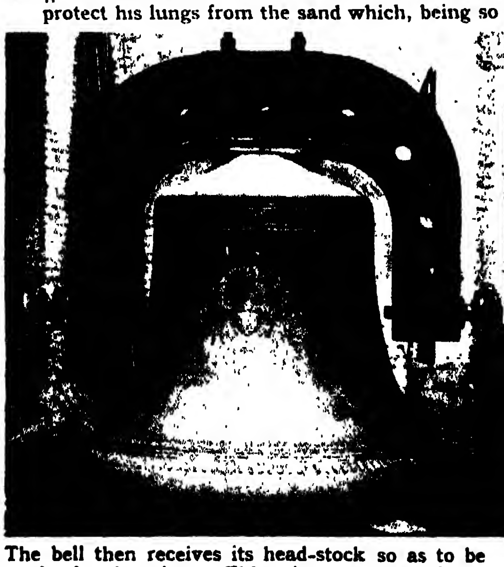
The molten metal is then poured into the space between the core and cope and is allowed to cool. Holes in the core allow air to escape as the metal enters

As soon as the metal is cold the cope is removed and the bell is then lifted off the core ready to be polished and tuned. In this photograph, a bell is seen inside a cope after the core has been removed

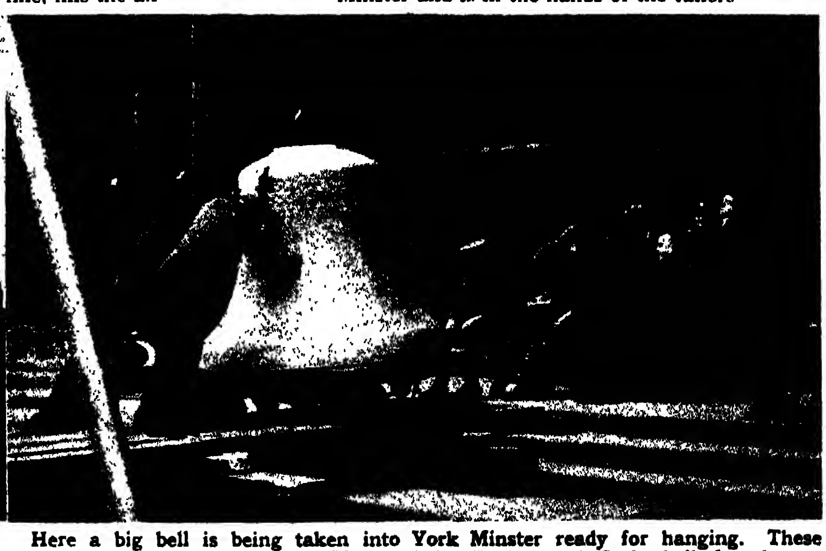
The bell is rough when it is removed from the mould and is smoothed by being sand-blasted as shown here. The workman wears a mask to protect his lungs from the sand which, being so fine, fills the air



The bell is tuned by the metal being thinned if the note is flat. The bell in the picture is Great Peter of York Minster and is in the hands of the tuners



The bell then receives its head-stock so as to be ready for hanging. This picture shows Great Peter of York, which weighs nearly 11 tons



Here a big bell is being taken into York Minster ready for hanging. These pictures were taken at the Messrs. John Taylor and Co.'s bell foundry at Loughborough, where some of the world's finest bells are cast

WONDERS of ANIMAL & PLANT LIFE

THE BIGGEST BRITISH WILD ANIMAL

The red deer which once roamed all over Britain is now found wild only in one or two places, chiefly the Highlands of Scotland and the moors of Devon and Somerset. It is a fine animal and has many interesting habits. It is the largest wild mammal we now have, and here we read many fascinating facts about it

THOUSANDS of years ago the elephant and the hippopotamus used to roam over England. Their remains have been found in many parts, including the valley of the Thames and the district in which London now stands. But the big animals have now disappeared, and the largest wild mammal that is to be found in the British Isles at the present time is the red deer.

It lives wild in the Highlands of Scotland, in Devon and Somerset, and in one or two other remote areas. There are also a number of parks and other places where tame herds are kept. The red deer is a fine animal, and a male deer, known as a stag or hart, with fine antlers or horns upon its head, is a majestic creature.

In the young stags these antlers have blood circulating in them, but at a later stage there is no blood, and the horns are not sensitive to pain. The skin on them eventually peels off and leaves the horns bare.

In its second year a male deer is called by huntsmen and stalkers a brocket, in the third year a spayad, in the fourth year a staggard, in the fifth a stag, and in the sixth a hart.

In Britain the red deer never grows to such a great size as it does on the continent of Europe, but even in Scotland a stag may weigh as much as 420 pounds and stand four feet high at the shoulder. An average British stag, however, weighs between two and three hundred pounds.

There is a long fringe of hair on the throat, corresponding to a lion's mane, and in the pairing season this develops and becomes still more impressive. As may be supposed, the colour of the red deer during the summer months is a bright reddish brown, though the hair on the head, legs and throat is greyish. But in winter the fur becomes longer and softer and the colour of the animal tends to become a brownish grey.

It is only the male that has antlers. They rise from the frontal bone, and there is a round ring at the base. The main stem is called the beam, and the branches have points which are known as tines. Stags have been found with as many as 60 points, but living specimens in the British Isles have far fewer tines than this. Indeed, they rarely exceed a dozen.

The antlers form formidable weapons, and at the pairing season the males may often be seen fighting while the hinds, or females, stand by. Occasionally the stags get their antlers so entangled that they cannot release themselves, and both perish. They are sometimes found lying dead in this condition.

The antlers are shed each year about February or March, after the breeding season is over, and sometimes they are eaten by the hinds. A new pair very soon grows to take the place of those shed.

There is no doubt that the size of the antlers depends very largely on the food the animal eats, and as in

The red deer is very fond of water, and is a good swimmer. Not only when it is hunted does it take to the water, but it does so for sheer pleasure. Sometimes it goes right under the water except for its nostrils, which are held above the surface so that it can breathe. At other times it will roll over and over and then stand up and shake itself like a dog

A FINE SPECIMEN OF A BRITISH RED DEER

A fine specimen of the British red deer like the one shown here stands about four feet high at the shoulder and may weigh nearly four hundredweights The antlers are sometimes three feet long On the Continent of Europe, where the red deer grows even larger, the antlers have more points than the British specimens Red deer have been known with as many as 66 points on their antlers In summer the animal s coat is a bright reddish brown hence its name, but in winter this tends to change to a brownish grey Wild stags have occasionally been found quite white The hair on the throat, as can be seen in the picture, forms a long fringe, which adds to the grandeur of the animal It is well named "The Monarch of the Glen" The antlers are possessed only by the males and are shed yearly

Great Britain the red deer has been slowly driven away from the best pastures by advancing civilisation, it has degenerated. The antlers of prehistoric deer, which are dug up from time to time in England, are far finer than those produced to-day. At one time, when the British Islands were covered with almost uninterrupted forest, the red deer ranged the whole country.

A Regular System of Etiquette

The pairing season begins towards the end of September or at the beginning of October and lasts for about three weeks. During that time the stags are very quarrelsome, and it is dangerous to approach them. But at other seasons of the year they keep apart from the hinds and generally feed on the higher ground while the hinds and young find their food below.

The stags follow a regular system of etiquette, according to Mr Fred Goss, a great authority on these animals. An old and experienced master stag, he tells us, leads the herd in single file and every few hundred yards or so stops to look round and sniff the air for signs of danger. The rest of the herd also stops and none ever attempts to get in front of the leader.

If this stag satisfies himself that all is well, he starts off again followed by the line. At last when he reaches a suitable place for resting he halts, turns round and faces his followers and makes what looks for all the world like a bow.

"This," says Mr Goss, "signifies their dismissal, and the great personage thereupon proceeds to walk off haughtily into the fern to find himself a comfortable place on which to lie. Having found a spot to his liking he turns round a few times like a dog making his bed and leisurely settles down. On their dismissal his retinue likewise disperse to their beds. In doing so they must not lie down near enough to encroach on their leader's privacy. Nor on the other hand must they go too far away, for old stags, whether on the moor or in the woods, always like to have younger ones close at hand for drawing off hounds or bearing the brunt of other dangers which their elders feel disinclined to face."

It is said that sometimes stags will leap over the last few yards at the end of a journey so as to break the continuity of scent between their tracks and their lair.

A Foe of the Farmer

Red deer are very destructive creatures. In a turnip field they will take two or three bites at a turnip and as soon as it is dragged loose from the ground they will leave it and start on another. In this way nearly a whole field of turnips can be ruined in a night. They are also very destructive to growing corn, and will not only eat off the ear but will lie down in the corn crushing it badly.

Deer are fond of mountain ash berries, and Mr Fred Goss tells us that he has seen old stags stand up on their hind legs and rattle the trees with their antlers to bring the berries down. They also raid orchards and do much damage to the apples. They are particularly fond of sweet varieties. They sometimes eat blackberries. Speaking generally, the food of the red deer consists of grasses, heather, toadstools, acorns and such fare. It is also very fond of salt, and takes a certain quantity wherever rock salt is available.

The Deer's Fondness for Bathing

Deer are good swimmers and like the water. At certain seasons they choose muddy ponds and roll over and over, wallowing in the slime until they are almost covered. Then they stand up and shake themselves like dogs.

When pursued by hounds they will often go into the water and lie down so that they are right out of sight, except for the tips of their noses, which are held above the surface so that they can breathe.

A fisherman with a net was once astounded to find that his net had become entangled with a stag, which thereupon started swimming across the river, taking the fisherman with it.

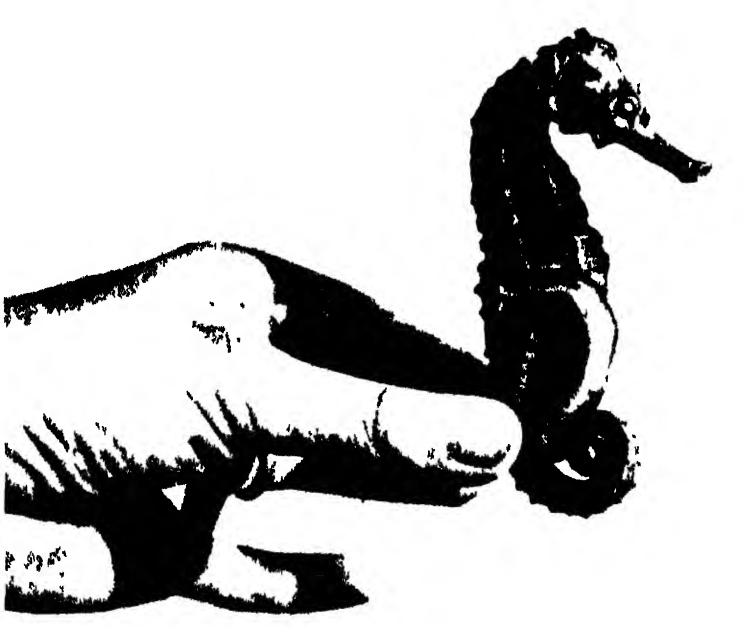
The female red deer has one fawn at a time, and this is spotted at first, but as it grows the spots disappear.

An ancient belief attributed remarkably long life to the red deer. According to tradition several stags in Scotland lived for over a hundred years. This, however, is a myth, for in parks deer reach their prime at twelve, and seldom live for more than twenty years.

THE QUEER LITTLE SEA-HORSE AND ITS WAYS

There are some strange fish in the sea, but it is doubtful if we could find anywhere a fish so queer as the little sea-horse. When we see it we can hardly believe that it is a fish at all, for in shape it has very little resemblance to a fish and the head is remarkably like that of a sculptured or heraldic horse.

There are many different species of sea-horse, and they range from the Atlantic and Mediterranean to Australian waters. Occasionally they are found round the British coasts. They all have more or less the same form, though some have many streamers on their bodies, which give them the appearance of seaweed.



The little sea-horse which is really a fish. It attaches itself to the seaweed and coral by curling its tail round the stems

The sea-horses are, indeed, very well camouflaged and closely resemble the colour of the seaweeds to which they attach themselves by their funny little curly tails. They always look perky, and it is worth while going to the Aquarium at the London Zoo simply to see the sea-horses. Generally they are only a few inches long, but some species are at least a foot in length from nose to tail.

Sometimes these little creatures hold together by linking their tails.

The male sea-horse has a kind of pouch made of soft membranous skin which lines a groove on the under surface of the tail, and when the female lays her eggs her mate puts these in his pocket, and there they remain till the young sea horses hatch out.

HEDGEHOGS OF THE PLANT WORLD

The name cactus, given to a whole family of strange flowering plants that are quite unlike any other plants, is a Latin form of the Greek name kaktos. This name was originally given by the ancient Greeks to a plant with spines which grew in their country. It is now used for a group of fleshy-stemmed plants, natives of America, many of which have developed formidable spines as a protection against animal foes. Here we read many interesting facts about these queerly shaped members of the Cactus family.

We are all familiar with the strange forms of those queer plants known as cactuses. The plural is sometimes given in its Latin form cacti. Perhaps we grow them ourselves in pots in the greenhouse, for in recent years their cultivation has become rather a fashion in England and other countries where they do not naturally grow wild. At any rate we have seen them in botanical gardens, and we may have wondered why they are so unlike other plants, why they appear to have no leaves, and why they are so prickly, and so on.

They are really exceedingly interesting plants, and are a remarkable illustration of how Nature adapts itself to circumstances. These plants, the various cacti known as the torch thistles, the hedgehogs, prickly pears and so on, are natives of the dry sunny regions of America.

The Camel and the Cactus

They are not found in actual deserts, but in arid country where sometimes for months at a time no rain falls. If they were like ordinary plants the cacti would be unable to live, and so they have changed their form and character so that they may live often for months at a time when there is no water available.

We know how the camel is adapted to live in dry regions. A train of camels can cross a desert for days together without drinking, simply because the bodies of the animals have in the course of ages developed an apparatus in which a great deal of water can be stored. Then when no water is available the camel can draw on its internal cistern.

Adaptation to Circumstances

Something of the same kind has happened in the case of the cacti. An ordinary plant, such as an elm tree or a gooseberry bush or a buttercup, sucks up water through its roots from the soil and gives out moisture through its leaves, and it is able to live because in the countries where it is found an ordinary tree or bush or plant finds plenty of water, and so a constant stream is passing through it from the roots to the leaves and off into the atmosphere.

But if the cactus were to do the same thing it would soon find that after it had given off moisture to the air there was no more water to suck up from the soil, for the soil is perfectly dry for months on end.

What has the cactus done to meet this difficult situation? Well, in the course of ages it has got rid of its leaves, that is, leaves in the ordinary popular sense, and it has thickened its stem till we see the strange forms which these plants now take.

Sometimes they are as round as a football, and in this connection it is interesting to remember that they are approaching to a perfect sphere, the solid in which there is the smallest amount of surface for the cubic contents of all possible shapes. Sometimes the main stem and the branches are all about the same thickness and go up straight like organ pipes. The cactus has done all this for the same reason that a man builds a cistern. It needed a store place in which to keep water for the dry season. We often talk of "laying by for a rainy day," but the cactus reverses the process and lays by for a dry day, and very efficiently it does this.

An enormous organ cactus growing in the Arizona desert. It is over sixty feet high, and its great size may be judged by comparing it with the horseman on the left-hand side at the back

One distinguished botanist has very aptly described these strangely formed plants by saying that they have "condensed stems."

The greatly thickened stem enables the plant, when it sucks up water from the soil, to store this in cells in its fleshy interior. But something more was needed than a mere store place. A hard covering of close texture was necessary to prevent the store thus laid by from evaporating when the hot sun poured down upon the plant.

Resisting the Sun's Heat

The cactus met this difficulty by hardening its outer skin or bark. It has become as hard and shiny as glass, and no matter how fiercely the sun shines or how continuously the dry hot wind may blow, the cactus is able to retain its store of water, so carefully laid up, and hold out for months at a time.

When one of the American giant cacti was dried it did not lose the whole of its water for 570 days, that is, more than a year and a half. We can see, therefore, why it is that when other vegetation fails to get a hold on the arid lands of the American continent the cacti thrive and flourish.

Taking Carbon from the Air

But there are two other things that the cacti have done in order to adapt themselves to the life they have to live and the circumstances in which they find themselves. They need carbon, and this they cannot take up from the soil; they must obtain it from the carbon dioxide gas in the atmosphere by means of a substance known as chlorophyll, which gives the green colour to plants.

Under the action of light the carbon dioxide gas is broken up, its oxygen being restored to the atmosphere, while the carbon is united chemically with the water and mineral substances sucked up through the roots to form new combinations and build up the plant, enabling it to grow and become healthy.

These changes, so necessary to the life of the plant, can only go on in the green parts where chlorophyll is present. Now we know that the bark of an ordinary tree like the oak or ash is not green, but brown. Such a

PLANTS THAT STORE UP WATER FOR DRY DAYS


On the left we see a man gathering the fruit of the prickly pear cactus which is good for food, although the plant is in many countries as in Australia a great pest because it spreads so rapidly On the right is an interesting collection of cacti grown in pots The large spiny plant like a vegetable marrow with pins all over it is a hedgehog cactus This kind of cactus sometimes grows seven feet high and weighs a ton The form of a cactus plant enables it to store up large quantities of water for the dry season

This photograph, taken in California, gives a very good idea of the strange appearance of the tall pipe or column like cacti Some are as uniformly straight as pipes, while others are jointed from top to bottom They are all very stout in texture, and in Mexico and other countries are often planted in rows to form fences which are practically impassable A thick prickly pear fence with its many spines, is an even more formidable barrier against both man and animals

plant feeds through its leaves where the chlorophyll is present. But now that the cactus has got rid of its leaves, how is it to feed and build up new tissue?

Well, it has got over the difficulty by seeing that its outside, that is, its bark, shall contain chlorophyll, and it is here that it takes the carbon from the carbon dioxide of the atmosphere and with it forms the compounds that build up tissues. That is why the bark or outside of the giant cacti which grow in the American bad lands, as they are called, is green.

There is one other very necessary adaptation which the cactus has had to make in order to survive. Containing, as it does, a great store of water, it would be very useful indeed to animals that live in the desert. When any of them became thirsty, all it would have to do would be to go up to a cactus plant and eat it. It would then get not only food but drink as well.

The cactus has provided against this by arming itself. Most of the species have become vegetable hedgehogs or porcupines. They have changed their leaves into sharp prickly spines, and the work of the leaves now is not to seize the carbon from the air's carbon dioxide and combine it with water and other minerals sucked up by the roots, for that work, as we have explained, is now done by the stems and branches. On the contrary, the work of these adapted leaves is to protect the plant from the attack of animals, and very successfully they do so.

In the great arid territories of America millions of cactus plants grow full of nourishing food and excellent water for cattle, but the cattle cannot get through their defences. If they ate the cacti the prickles would perforate their insides and they would die, and so the cactus is left alone to thrive and flourish.

It may seem a contradiction of these statements that the wild asses and horses of South America often root up and trample on the cactus with their hoofs in order to get at the juicy tissue. But it must be remembered that horses and asses are not native animals of America; they were introduced after the discovery of America by Columbus, and the cacti never provided for defence against such unusual creatures. Nevertheless, the horses and the asses often receive very dangerous wounds from the terrible spines of some of the cacti like the melon thistles or Turk's-cap cacti of Mexico and Brazil.

Some forms of cactus, like the hedgehog cactus, sometimes have as many as 50,000 spines on a single plant. The Mexicans gather these spines and use them as toothpicks. The spines of other species of cactus are now collected and used as gramophone needles.

A group of hedgehog cacti grown in pots in England

To show how efficiently the cactus has adapted itself for the storage and non-evaporation of water by its peculiar shape, it may be mentioned that a hedgehog cactus which was examined was found to expose three hundred times less surface for the amount of matter in it than the leaf of the well-known climbing plant, often cultivated in hothouses, called aristolochia. The aristolochia plant loses 5,000 times as much water per square inch as the cactus.

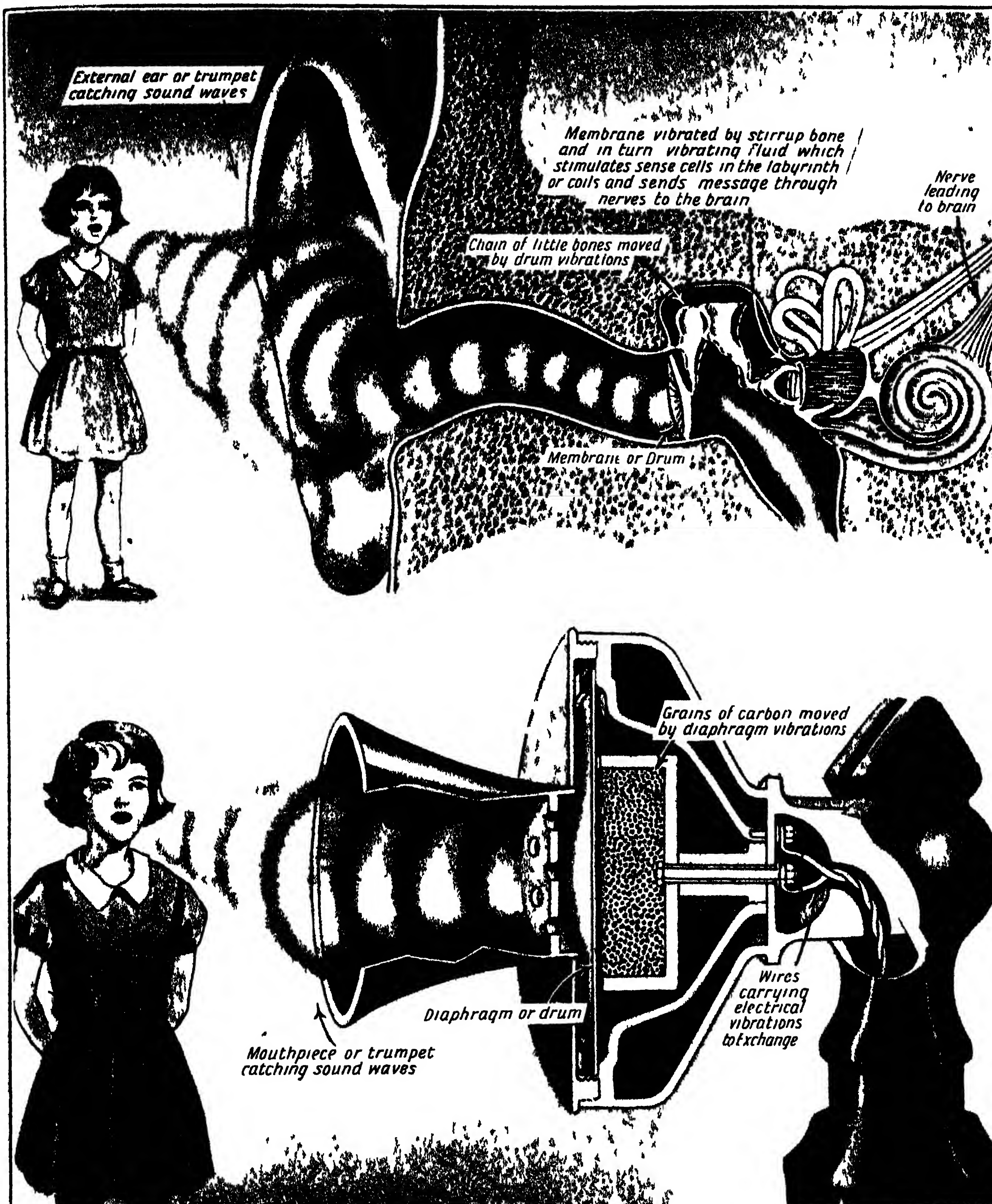
How adaptable the cactus is to dry, sunny lands is shown by the story of the opuntia or prickly pear in Australia. It is not a natural plant of that island continent, but was introduced. It found the conditions very favourable, and, taking advantage of these, it spread so rapidly that it has now become one of the greatest pests in Australia. Large areas that were once cultivated have been overrun by the prickly pear, and it has become necessary to introduce an insect pest which preys on the opuntia. We read about this in another part of this book.

Many of the cacti produce beautiful flowers and luscious fruits. Of these we also read in another part of this book. It is certainly an interesting hobby to keep a number of cacti in pots.

THE WONDERFUL MOSAICS MADE BY THE LEAVES

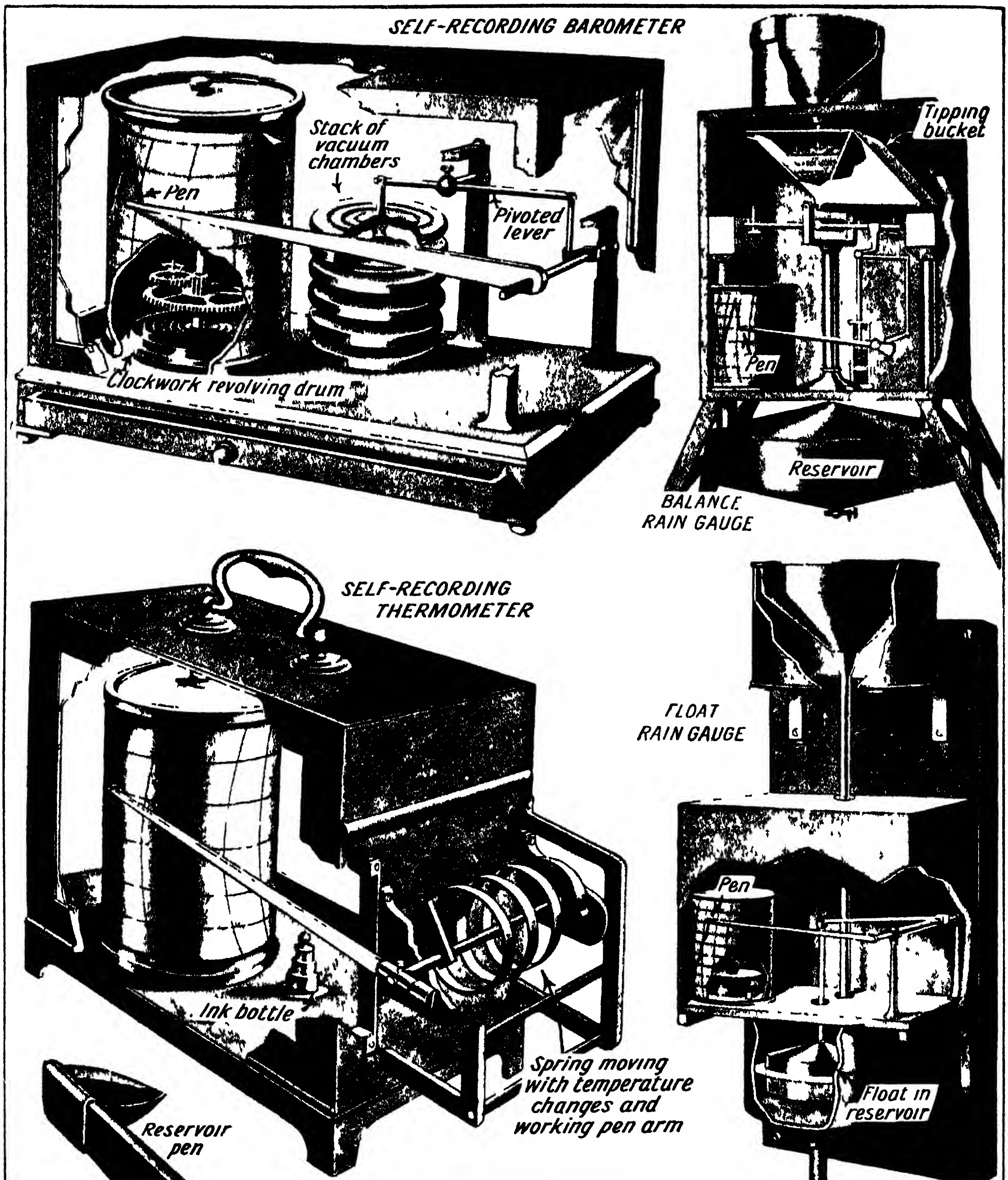
Without its leaves a plant cannot thrive, and that is why if caterpillars keep eating the leaves of a tree the tree must eventually perish. The food materials taken up by the roots are carried to the leaves unchanged, and it is by means of the chlorophyll or green colouring matter in these leaves, together with carbon-dioxide gas absorbed from the air through the stomata or breathing holes of the leaves, that the food materials are changed and made suitable for the building up of the plant. But the changes can only take place in the light, and so the leaves must receive plenty of light. In order that they may receive all possible light they arrange themselves on a plant in wonderful mosaic form, so as to expose every possible part to the light. Some specimens of this mosaic work of the plants are seen in these pictures. The deadly nightshade produces miniature leaves to fill up the spaces between the larger ones.

INSIDE OUR EAR AND INSIDE A TELEPHONE



When someone sings or speaks, the sounds set up waves in the air These enter our outer ear, pass down a channel or canal, and strike upon a membrane called the drum This vibrates and sets moving a chain of three little bones, called from their shape the hammer, the anvil and the stirrup The last named vibrates another membrane, which in turn vibrates a fluid, and the motion is passed on till it stimulates the nerve of hearing, and a message is sent to the hearing centre of the brain, which distinguishes different kinds of sound It is not really the ear that hears, but the mind of man The telephone is very similar to the human ear Sound waves enter the mouthpiece, vibrate a diaphragm, which sets a number of grains of carbon moving, thereby affecting an electrical current passing through them, and the vibrations are transmitted by the current through wires to a receiving instrument at the other end, where they are translated back into sound and we hear them as we hold the receiver to our ear

SELF-RECORDING WEATHER INSTRUMENTS



These pictures show how some self-recording weather instruments work In the top left-hand picture is a barograph or self-recording barometer which records the changing pressure of the air by drawing a line on a sheet of paper It is an aneroid barometer, but instead of having one vacuum box like that shown on page 427 it has a stack of six and the depression or expansion of these moves a pivoted lever which turns a shaft to which a long pen is attached A chart on a drum is revolved at a slow pace by clockwork and as it moves round the pen draws a graph or line on the paper, its position changing with the changes in the pressure of the atmosphere Underneath at the left is shown a thermograph or self-recording thermometer Here the same principle is carried out except that the pen is moved by a spiral spring of metal which changes its length with the changes of temperature and coils or uncoils with these changes The pen has a little reservoir which is filled with ink The other instruments shown are self-recording rain-gauges The top one has a bucket divided into two equal parts When one is filled with rain it tips over, moving a series of levers and working a pen which draws a line on a chart revolved by clockwork The other division of the bucket is then brought into position ready to operate when filled In the bottom rain gauge the pen is worked through a series of levers by a float which rises as the rain collected fills a reservoir to which it passes from the funnel at the top by a pipe These self-recording instruments give valuable continuous records

MARVELS of CHEMISTRY & PHYSICS

THE MYSTERY OF THE BURNING GLASS

Even a small convex lens or magnifying glass will concentrate the Sun's rays so that they become powerful enough in summer time to set light to paper or wood. This device, on a large scale, has even been suggested as a weapon of defence, and there are stories that it was so used in ancient times. Here we read about the burning glass and the explanation of its strange power

Most of us know that if we hold a magnifying lens such as an ordinary reading glass so as to catch the Sun's rays a very bright point of light will be projected or thrown beyond the glass and that this will have very great heat, much greater than the rays of the Sun unassisted by the glass. Why is this?

Well, the reading glass is a double convex lens, that is, it is a lens in which there is a bulge outward on both sides. The rays of the Sun strike one side of this lens and then pass through the glass to the other side, but in the process the rays are bent at an angle, and so the parallel rays which strike the glass at different parts of its surface are all brought to a focus or meet in a place at one point. This can be seen clearly in the upper picture on this page.

Naturally, when all the different rays are brought together at one point, there is much greater heat there than at any point where only one or two rays strike. The result is that when a reading glass is used in this way it becomes a burning glass, and paper or even wood can be set alight by the action of the concentrated heat.

Summer Experiments

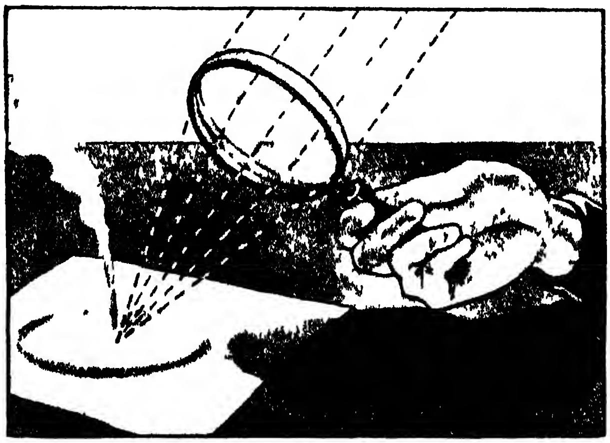
In summer time some interesting experiments can be performed with a reading glass in this way. They had better be carried out in the open air so that there may be no danger of setting light to anything of value indoors. Boy scouts and campers out, for example, can light a camp fire made up of sticks and dry leaves by merely focussing upon one part of it the Sun's rays from a magnifying lens.

It is important to remember the power of the Sun's rays when concentrated in this way. Rooms have been set on fire before now and much damage done by the Sun shining through a window and being focussed by a glass bottle or jug full of water upon a book or table cloth. The vessel of water acts as a burning glass and sets fire to the inflammable material on which the rays are directed.

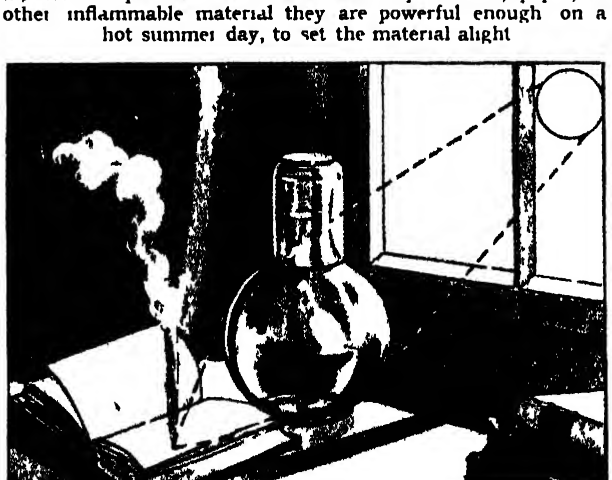
That is why it is always important that a glass bottle or jug of water should never be left in an exposed position near a window through which the Sun is shining or is likely to shine.

The same result can be obtained by using a concave mirror. The parallel rays of the Sun strike this at its various points and are reflected at an angle so that they are all focussed or concentrated upon a single point and great heat results.

We are not certain who first discovered the power of convex lenses and concave mirrors. According to tradition it was that great scientist of ancient times, Archimedes. The story goes that when the Romans under the Consul Marcellus besieged the city of Syracuse in Sicily in the year 212 B.C. their ships were set alight by means of burning glasses invented by Archimedes, who at the time was 75 years of age.



When the Sun's rays which reach the surface of a magnifying lens in parallel lines are focussed upon wood, paper, or other inflammable material they are powerful enough on a hot summer day, to set the material alight



Even a glass jug or bottle of water in the direct line of the Sun's rays will act as a burning glass, and fires have been caused on many occasions in this way. Of course, the Sun is so far off that all its rays really reach us in parallel lines

The historian Edward Gibbon tells another story of how Proclus the philosopher destroyed the Gothic vessels in the harbour of Constantinople by the same means. A machine was fixed on the walls of the city, he says, consisting of a hexagon mirror of polished brass with many smaller and movable polygons to receive and reflect the rays of the meridian sun, and a consuming flame was directed to the distance perhaps of two hundred feet.

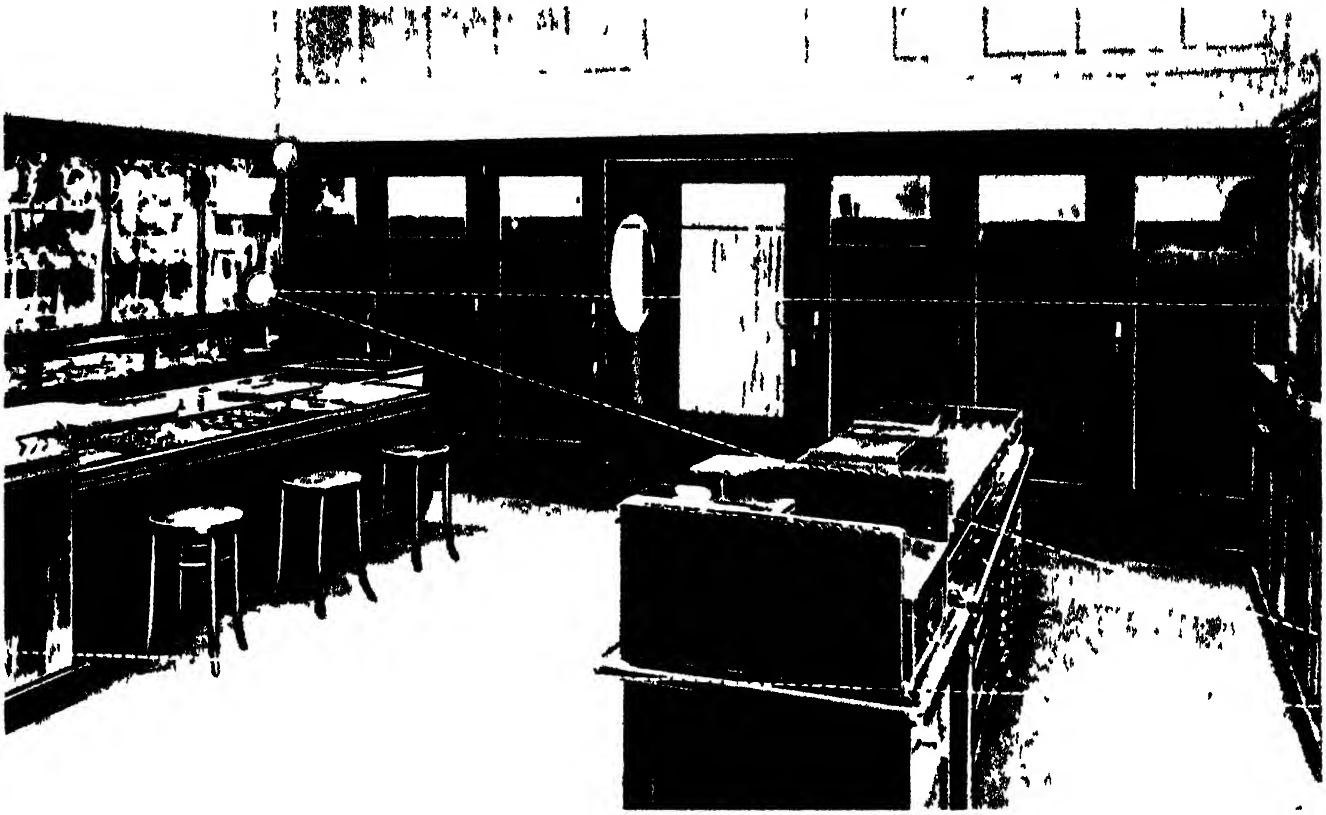
Although the most reliable ancient historians of the period do not refer to the burning glasses of Archimedes or the burning mirrors of Proclus, Gibbon thinks the stories are quite likely to be true. It is more reasonable, he thinks, to regard the traditions as facts than to suppose that they were imagined by monks of later days.

A Great Burning Glass

If these ancient scientists really discovered the power of burning glasses and mirrors, then their knowledge was afterward lost for centuries. We find no further reference to such devices till the sixteenth and seventeenth centuries, when John Napier, the Scotsman who invented logarithms, mentions them as useful for defence. The biggest ever constructed was made by an Englishman named Parker about 1800. It cost £700, and with it gold, silver, copper, iron, steel, topaz, emerald, flint, cornelian and pumice stone were fused or melted. It was afterwards taken to Pekin, but what happened to it in the end is not known.

In Paris there used to be a time signal which consisted of a gun that was fired at noon by the Sun's rays focussed through a magnifying lens fixed in the necessary position.

THE INVISIBLE RAY AS A BURGLAR ALARM



All sorts of burglar alarms have been devised but the very latest and most scientific is the invisible ray which when anyone passes through it sets an alarm bell ringing. We have already seen on page 261 how a door can be opened automatically when a person passes through a ray of light shining across the entrance. The newest type of burglar alarm is of the same nature, only instead of a visible ray of light the ray is invisible. As can be seen by the dotted lines in this photograph, invisible rays are made to pass to and fro across the jeweller's shop or other apartment to be guarded. Each invisible ray shines upon a selenium cell, as described on page 261 and when the ray is broken by someone passing through it an electric circuit is completed and a bell is set ringing. The burglar cannot guard against working the alarm for he is unable to see the rays, and does not know in which direction they are passing.

HOW YOU CAN MAKE THE SUN UNCORK A BOTTLE

HERE is an interesting experiment which we can carry out when the Sun is shining. We know how when the wire that fastens the cork securely in a soda-water bottle is cut the cork flies out with a pop. Why is this? Well the reason is that the carbon-dioxide gas which is under pressure in the liquid inside is constantly pressing against the cork but cannot drive it out so long as the wire is intact. When however the wire is cut the pressure of the gas is strong enough to force the cork out. In other words there is a little explosion which sends the cork flying.

With this knowledge we can carry out our experiment. Take a bottle such as that in which vinegar is sold and when it is empty cork the mouth. The bottle has nothing inside but air and as it is not under pressure the cork remains in position.

On the left we see the carbon-dioxide blowing the cork out of a soda-water or lemonade bottle as soon as the wire is cut. On the right the sunshine has made the air blow the cork out of an empty bottle

Place the bottle on a table or shelf by a window through which the Sun is shining. After a time you will hear a pop and you will see that the cork has been blown out of the bottle. It is quite easy to understand how this happens. The hot sunshine pouring upon the bottle has made the air inside warmer and warmer, and as we know a gas expands when it is heated.

At last it expands so much and the pressure becomes so great that it pushes out the cork. Such an experiment is best performed in summer, when the Sun's rays are hot.

For the same reason, an air balloon blown out and left in the Sun often goes off with a bang. The air expands and bursts the fabric.

DRAKE SAILS ROUND THE WORLD

It was a great day when Sir Francis Drake arrived back at Plymouth in the *Golden Hind* after having sailed right round the world, the first English commander to perform such a feat, and, indeed the first commander of any nation to do it Ferdinand Magellan had set out to circumnavigate the globe nearly sixty years before, and his ship came safely back to Spain, but he himself was killed in the Philippine Islands, and so did not complete the journey Here we read the thrilling story of Drake's great voyage

THERE is little doubt that if a vote were taken as to who were the six greatest Englishmen of the last thousand years Sir Francis Drake would find a place among the six and it is quite possible that he would head the list Of course there have been statesmen and men of science who have done far more for the nation than Drake but he stands out as a typical Englishman with the qualities regarded in England as most desirable and his picturesque and dramatic career appeals to the imagination in a way the life of no scientist or statesman or reformer ever could do

Drake did many things and his life from beginning to end is an amazingly romantic story of action which seems almost incredible to us in these prosaic days But the outstanding event of his life was his voyage round the world in a little ship of 100 tons when in the picturesque phraseology of the old writer he ploughed up a furrow round the world

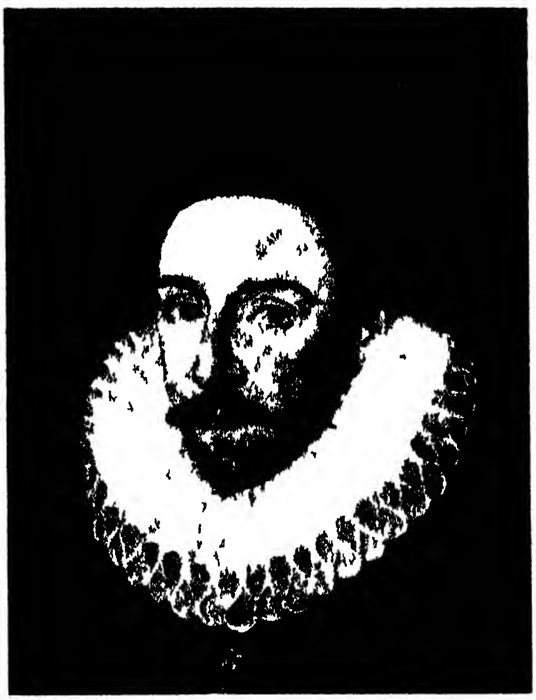
A Lost Leader

He was the very first commander to perform such a feat It is true Magellan's ship had made the journey half a century before but Magellan himself had lost his life in the Philippine Islands and so his expedition returned home under another commander Drake however commanded his vessel throughout the whole journey and after nearly three years of almost incredible adventures sailed triumphantly into Plymouth Harbour attributing his success to Providence as described by the historian in a Latin verse which may be translated thus

> To Him sole Author of all works immense
> To Him sole Ruler of earth and and sea
> To Him of all His own the great defence
> To God alone let all the glory be

Drake was a Devon man but we do not know a great deal about his family His father who seems to have suffered religious persecution, had no less than twelve sons, most of whom we are told became sailors the greater part dying at sea Francis Drake as a very young boy, was apprenticed to the master of a little vessel who when he died left the ship to the youth

Two years later we find Drake commanding a small vessel of 50 tons which formed part of a squadron fitted out by his relation Sir John Hawkins to capture slaves on the African coast and carry them for sale to the Spanish Possessions in America In a fight with the Spaniards all the vessels but two were destroyed one of which was the *Judith* commanded by Drake This and the other succeeded in reaching England and Drake who was sent to Sir William Cecil the statesman to give an account of the expedition thus came



Sir Francis Drake the first Englishman to sail round the world From the painting by F Pourbus

under the notice of Queen Elizabeth's great minister

Drake next made two expeditions to America on his own account during which he raided Spanish settlements captured a good deal of treasure and was badly wounded in one skirmish It was during the latter of these two expeditions that Drake heard of a certain tree from whose top might be discerned both the North Sea and the South Sea that is the Atlantic and the Pacific Oceans

The tree was on the summit of a very high hill and a friendly Indian taking Drake by the hands desired to walk up that goodly and great high tree in which there were cut steps to facilitate the ascent almost to the top In the midst of the branches a little arbour had been constructed large enough for about twelve men Drake ascended this famous tree and was the very first Englishman to see that ocean of which he had heard golden reports from Spanish sources

There in the tree we are told with great solemnity he besought God to give him life and leave once to sail an English ship in these seas and the historian adds He was heard in what he asked as will hereafter appear He vowed that he would make the attempt to sail the Pacific and from that time forward his mind was pricked on continually night and day to perform his vow

Chivalrous Behaviour

By taking Spanish ships and towns Drake obtained enough treasure to make himself a rich man for the rest of his life It is pleasing to read that on this expedition he strictly charged all his company and the friendly Indians who helped him that they should on no account hurt any female or unarmed man an order which we are told they all faithfully obeyed This behaviour characterised Drake in all his adventurous life He was never cruel he never killed either natives or Spaniards if he could avoid it and again and again he behaved with the utmost chivalry to his enemies

When his little ships returned to Plymouth in August 1573 the people were at church and the preacher in the midst of his sermon but news of Drake's return was carried into church and we are told that in a few minutes there remained few or no people with the preacher all running out to witness the blessing of God upon the dangerous adventures and enterprises of the captain who had spent one year two months and some odd days on this voyage

The news of Drake's daring and success made him many friends at Court and he had an interview with the Queen telling her some of his experiences Sir appears to have been

gracious to him and it is very likely that she encouraged him to further efforts although of course as she was at peace with Spain she could not instruct Drake openly to make attacks upon that country's treasure ships

Rather more than four years later Drake fitted out another expedition which consisted of five vessels his own ship the *Pelican* of 100 tons the *Elizabeth* of 80 tons manned by Captain John Wynter and three smaller ships the *Marigold* 30 tons the *Swan* 50 tons and the *Christopher* of 15 tons

There was evidently no want of funds in fitting out these vessels for we find the ships were supplied not only with all manner of necessaries for a long and hazardous voyage but with many articles of luxury All the vessels for the table in the *Pelican* and some even for the cook room are said to have been of silver No doubt they were part of the treasures the commander had captured on his earlier voyage

Music on Board

Drake took with him also musicians who could play on different instruments As he was a man of very plain and simple habits it is quite likely that these articles of luxury were taken not so much for his own comfort as to display the wealth and taste of his country in those parts of the world in which he was about to travel

Of course there were doctors on board and a preacher for even pirates were pious in those days

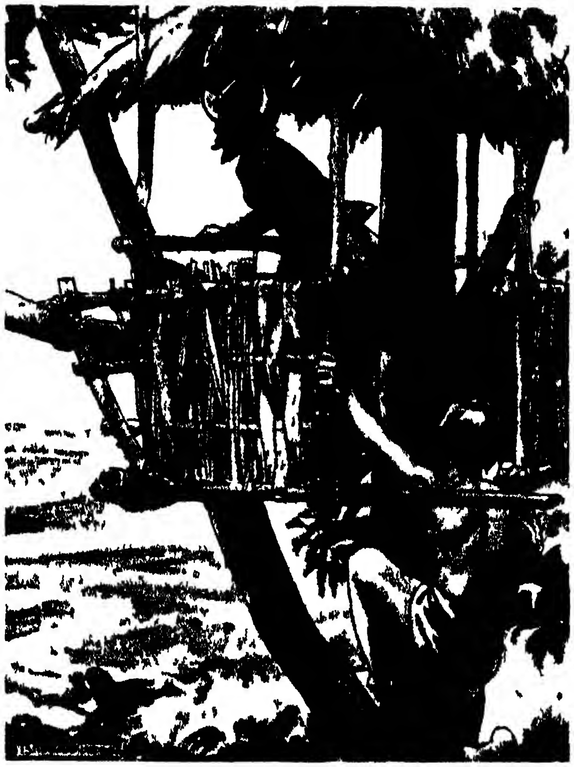
A great deal of secrecy was observed as to the object and destination of the voyage and Drake concealed these things even from his mariners and his personal friends He had however decided to go across to America prey on the Spanish ships and treasure cities and following in the wake of Magellan sail on the Pacific where hitherto no English ship had been seen

The little Armada of five tiny vessels manned by 163 seamen left Plymouth on November 15th 15-- but no sooner were they outside the harbour than a violent storm overtook them and compelled them to take shelter in Falmouth and then afterwards to return to Plymouth to make good certain damage that had been done

When the vessels were refitted Drake set sail from Plymouth a second time on December 13th and went south calling at Mogador on the coast of Barbary Water and provisions were taken on board and then the squadron proceeded to the Cape Verde Islands where they obtained a quantity of fruit

Seizing two Portuguese vessels they chased them and captured one which was laden with wine and other valuable articles Drake put twenty eight of his own men into this ship and took her master aboard his own vessel in order that he might act as a pilot on the coast of Brazil for which it was now declared the squadron was bound

Among Drake's party was a personal friend of his Mr John Doughty an educated man who was a volunteer in the expedition and Drake put him in command of the Portuguese prize Soon afterwards however he received complaints from other seamen that Doughty had purloined certain articles



Drake climbs up a "goodly and great high tree" and catches a glimpse of the Pacific Ocean

of value which should have been part of the common property of the expedition and Drake thereupon went on board to inquire into the matter and found a few trifling articles in Doughty's possession

A Change of Command

So far from purloining them there seems no doubt that they had been given to him by Portuguese on board and that in full view of the Englishmen who had charge of the vessel However Drake deposed Doughty and sent him aboard his own ship the *Pelican* as commander of that vessel Then he placed his brother Thomas Drake in charge of the prize and remained himself on board for a time

But soon there was trouble with Doughty on board the *Pelican* We are told by contemporary accounts that he was ' thought to be too peremptory and exceeded his authority, taking upon him too great a command by reason whereof such as had him in dislike took advantage against him to complain a second time '

Drake went on board the *Pelican* again removed Doughty from his command and making him a prisoner sent him for confinement to the *Swan*

We shall hear more of Doughty later but meanwhile the expedition continued its way crossed the Equator where for a time it was becalmed and experienced a good deal of thunder and lightning

Drake as always was very careful of his men's health and carrying out the practice of the day bled them or as the historian quaintly puts it let everyone of them blood on his own hand

At last the American coast hove in sight and Drake coming to the La Plata River saw multitudes of seals As these were found to provide good meat many of them were killed and a supply of provisions stored up in each vessel The expedition also saw what they believed to be ostriches but were really cassowaries whose thighs we are told were equal in size to reasonable legs of mutton '

A Meeting with Giants

On the journey south the *Swan* and the Portuguese prize which had been renamed the *Mary* were lost sight of for a time

The *Elizabeth* was sent to look for the missing ships and the *Swan* was soon found and brought in A landing was made and some trading done with the friendly natives These were scantily clothed but were giants in size and were the people whom the Spaniards had called Patagones which means paw footed men They had seen their huge foot prints in the snow We have altered the word slightly but still call the people Patagonians The *Swan* was now dismantled and broken up for firewood

The expedition then passed farther on and pausing to dismantle the *Christopher* which was abandoned proceeded southward and anchored in Port St Julian There unfortunately one of the men Robert Wynter partly in sport and partly to show English dexterity pulled the string of his bow with undue force in order to show how far he could shoot The string broke and while he was fixing it again some natives apparently having misunderstood his action shot their arrows at him and wounded him in the shoulder

Then another arrow pierced his lungs A gunner thereupon took aim at the natives with his musket but it misfired and before he could aim again he was slain by an arrow Drake then took a fowling-piece and shot at the native who first began the trouble The man was struck and we are told

his cry "was so hideous and terrible a roar as if ten bulls had joined together in roaring." The Patagonians thereupon dispersed. Robert Wynter died and he and the gunner were buried in one grave with martial honours and a sermon was preached.

One of the first objects that caught the attention of the voyagers at this place was the remains of a gibbet. Some seventy years before, when Magellan called there on his journey round the world, he executed a number of mutineers, and this gibbet was supposed to be the one on which the men had been hanged. No one dreamed when they saw the object that there would be an execution in connection with the present expedition at the same place.

Now we return to Mr. Doughty. The whole business in connection with him is a mystery. Apparently he was charged with trying to raise a mutiny in the fleet. At any rate he was brought to trial for this, found guilty by twelve men and sentenced to death and beheaded.

An Unsolved Mystery

What the evidence was we do not know, and later on in England there were enemies of Drake who suggested that he was put to death out of rivalry or at the request of the Earl of Leicester, whom Doughty was said to have offended. The fact however remains that Drake seems always to have acted with the most scrupulous fairness to his men. No member of the expedition ever suggested that he acted unjustly in this matter, or that Doughty had not deserved his fate.

Some say he had intended to kill Drake, but whether that be so or not he was reconciled to his old friend, asked that he might receive the Holy Communion in company with Drake at the hands of Mr. Fletcher the preacher, and before being beheaded embraced the commander and took his leave of all the company with prayers for the Queen's majesty. Then he quietly laid his head on the block and his life was ended.

Mr. Fletcher the chaplain speaks of Doughty in the highest terms as a man of endowments and ability. He was not a seaman and what possible object he could have had in wanting to destroy Drake or stir up a mutiny it is difficult to see. He had no friends or confederates in the squadron, and Drake was so beloved by his whole crew that had he been killed Doughty would probably have been torn to pieces by the crew.

One thing is certain. That Drake is always spoken of by those who knew him and travelled with him as a mild, indulgent and humane man, universally beloved by seamen. Doughty was buried, and a large grinding stone which was found broken in two parts was set up to mark the grave, one half at the head and the other at the foot. Some of the wood from Magellan's old gibbet was taken by the ship's cooper and made into tankards for some of the company to drink from.

The Portuguese prize, the *Mary*, which had rejoined the squadron, proving very leaky, was now unloaded and broken up, and the fleet was reduced to three vessels, the *Pelican*, the *Elizabeth* and the *Marigold*. The journey was continued, and soon Drake came to the mouth of the Straits of Magellan. Before entering these he changed the name of his ship, the *Pelican*, to the *Golden Hind* in honour of a friend of his, Sir Christopher Hatton, Vice-Chamberlain at Elizabeth's court, whose crest was a golden hind.

There were prayers of thanksgiving, Mr. Fletcher preached a sermon, and then the expedition entered the narrow straits. After sixteen days they passed out into the Pacific, but found it anything but a pacific sea, for it was very rough and turbulent and a terrible tempest scattered the fleet. It was the second time that ships had ever passed through the straits and entered the Pacific Ocean.

Near the western outlet an island was seen, and some of the men landed and called the place Elizabetha after the Queen. There were many penguins and the crew amused themselves by killing 3,000 in one day, presumably for food. We may marvel that Drake took only sixteen days to pass through the straits with his little vessels, for even up to the middle of the nineteenth century, when sailing ships had been brought to perfection, the journey required a fortnight.

Another tempest now arose and Drake's vessel was driven south, and he became the first man to see the union of the Atlantic and Pacific Oceans. The *Marigold* disappeared and was never again heard of, and all on board must have perished. The *Golden Hind* and the *Elizabeth*, however, continued their journey and entered a bay near the western entrance of the straits where they anchored, but a few hours later the cable of the *Golden Hind* parted and he drove out to sea, being thus separated from the *Elizabeth*.

The local chief placed a feathered cap on Drake's head and the English Admiral assumed that this was a token that the chief was handing over his country to the visitors

Alone on a New Sea

That vessel made no attempt to follow Drake, and the next day, taking advantage of his commander's absence, Captain Wynter re-entered the straits and despite the protest of his mariners started back for England. His was the first vessel to make the west to east passage of the straits.

Drake was now left with only his own ship except for a little pinnace which could be taken to pieces and packed away on board. Soon afterwards this boat with eight men in her was lost sight of, and not long afterwards was dashed to pieces among the rocks, the men being attacked and captured by Indians.

With a greatly reduced crew Drake continued his journey north, and we are quaintly told that as the ship had returned her old name of *Pelican* she might now indeed have been said to be "a pelican alone in the wilderness."

Coming to an island Drake and some of his men landed, but they were attacked by Indians and Drake himself was shot in the face by an arrow and nine other men were badly wounded. The chief surgeon had previously died and the other one was in the *Elizabeth*, which unknown to Drake had put back to England. The wounded therefore had to be placed in the care of a boy who we are told had little experience and no skill. No wonder when

all the wounded recovered it was felt that Providence had miraculously effected a cure. Apparently the natives mistook the English for the Spaniards who invariably treated them cruelly, and it is pleasant to know that Drake, realising this, would allow no reprisals

The journey was continued, and at the next place where Drake landed the natives were courteous and brought supplies of food, but as they could not give all that was needed they offered to pilot the *Golden Hind* to a port a little to the southward where larger supplies could be obtained Drake accepted the offer, and being guided to Valparaiso, obtained all he wanted He rewarded the Indian pilot for the trouble he had taken and all the kindness he had shown

After further adventures the voyage was continued Some of the crew landed at Tarapaca to search for water. Curiously enough they found a Spaniard asleep with a bundle by his side containing thirteen bars of silver. Drake would not allow them to do any harm to the sleeper, but told them to carry away the treasure quietly, some of the men jokingly remarking that the man on waking would be thankful to have been thus eased of so heavy a burden

More Treasure

At another place when Drake's men landed they found a Spaniard driving eight llamas, each laden with a hundred pounds' weight of silver. This treasure also was seized and the llamas driven down to the shore We are amusingly told that they obeyed their English drivers as well as they did the Spaniards.

Soon after Drake arrived at Callao, the port of Lima, and having entered the harbour without resistance, found thirty ships lying there, seventeen of them already prepared for their voyage It is amazing that the fear due to surprise caused by Drake's sudden arrival in a sea where no English ships were supposed to be, so paralysed the Spaniards that they allowed the little crew of Englishmen to plunder the seventeen laden ships and carry off all they wanted

On one vessel were found 1,500 bars of silver and in another a large chest of coined money. Drake then ordered the cables of the ships to be cut, allowing them to float about the harbour so that there might be no immediate pursuit. He had heard news of a rich ship laden with gold and silver that had sailed from Callao shortly before he arrived, and was bound for Panama. She was described as "the great glory of the South Sea."

Drake gave chase, caught her, and captured a large quantity of pearls and precious stones, eighty pounds' weight of gold, thirteen chests of silver and coined and rough silver enough to ballast a ship. All this was transferred to the *Golden Hind*. The Spanish ship's name was *Cacafuego*, which means Spitfire. It is said that a Spanish boy on the rifled ship said jokingly: "You may let your ship for the future be called *Cacafuego* and ours *Cacaplata*." This last word means Spit-silver.

Seeking a Northern Passage

Other ships were caught and rifled, and Drake now decided to travel north and see if he could regain the Atlantic by a northern passage similar to that of the Straits of Magellan in the south. It seemed to him likely that the Pacific and the Atlantic would be united in the north as well as in the south. The farther he went north, however, the colder the weather became.

"The very ropes of our ship," says the account of the voyage, "were stiff and the rain which fell was an unnatural and frozen substance, so that we seemed rather to be in the frozen zone than anywhere so near unto the sun or these hotter climates . . . Our meat as soon as it was removed from the fire would presently in a manner be frozen up; and our ropes and tackling in a few days were grown to that stiffness that what three men before were able with them to perform, now six men with their best strength and utmost endeavours were hardly able to accomplish."

It is amusing to read how easily these sixteenth century seamen were able to salve their consciences and convince themselves on very slight evidence that they were doing what was right. At one place where Drake landed he was received with great respect by the local chief who placed a feathered cap on Drake's head, a chain round his neck, and saluted him by the name of Hioh, which was supposed to be his own name or to signify the chief. Drake thereupon supposed that the courteous action of the chief was meant to convey the whole country and its inhabitants to the newcomers. He gave the chief to understand in the best way he was able that he accepted the gift in the name and for the use of the Queen of England. How surprised the friendly chief would have been had he understood what the English captain said.

Finding there was no strait between the two oceans in the north, Drake now struck off across the Pacific. We must admire the boldness of these brave seamen who without any charts sailed unknown seas by day and night and succeeded in their quest.

Drake called at the Philippine Islands, at the Moluccas, at the Celebes, and at Java, and seems to have obtained golden opinions from all with whom he dealt. At the Celebes it was noted that swarms of fire-flies were seen among the trees at night "as if every twig had been a burning candle."

Queen Elizabeth knighting Francis Drake on board his ship at Deptford. From a drawing by John Gilbert, R.A.

A Crab Dinner

The seamen found land crabs which they called crayfish, and they described them as "of exceeding bigness, one whereof was sufficient for four hungry stomachs at a dinner, being also very good and restoring meat whereof we had experience, and they dig themselves holes in the earth like conies."

On the night of January 9th, 1580, while threading her way among the dangerous islands and shoals of the Celebes, the *Golden Hind* suddenly struck on a rock and stuck fast. At daylight every attempt was made to get her off and three tons of cloves, eight guns, and a quantity of meal and beans were thrown overboard to lighten the ship, without producing any visible effect.

In this state of distress the whole ship's company was summoned to prayers. "Commending ourselves unto the merciful hands of our most gracious God, for this purpose we presently fell prostrate and with joined prayers sent up to the throne of grace, humbly besought Almighty God to extend his mercy unto us in his son Christ Jesus; and so preparing as it were our necks unto the block, we every moment expected the final stroke to be given

unto us." It will be noted that despite their distress and their prayers, no attempt was made to throw any gold or silver overboard to lighten the ship.

However, at low water the ship gave a lurch and slipped off the ledge of rock, floating at once into deep water. Fortunately she suffered no damage, and the voyage was continued. A call was made at Java, and then the Cape of Good Hope was doubled without calling, the next place at which a landing was made being Sierra Leone. There a stop was made of two days to take in water, and oysters and fruit were also obtained.

On September 26th, 1580, the *Golden Hind* arrived at Plymouth. It was Monday, but in passing round the world the mariners had lost a day and supposed that it was Sunday. All Plymouth turned out to welcome Drake, and his men. The bells of the church rang from morning till night, and the whole day was spent in feasting and rejoicing. Drake made a hurried visit to his old home near Tavistock, and then went to London.

For a month or two he heard nothing from the Queen. Apparently she wanted to see if there would be any trouble with the Spanish sovereign over Drake's escapades and rifling of treasure ships.

At last on April 4th, 1581, Elizabeth went to dine at Deptford where the *Golden Hind* lay, and on its deck knighted Drake as a reward for his services. She also granted him as arms a ship on the world.

It was a great honour, for in those days knighthoods were given only for real merit.

A Monument of England's Glory

The Queen expressed herself strongly that the *Golden Hind* should be preserved as a monument of Drake's and England's glory, and for many years it remained in Deptford Dockyard, an object of curiosity and admiration.

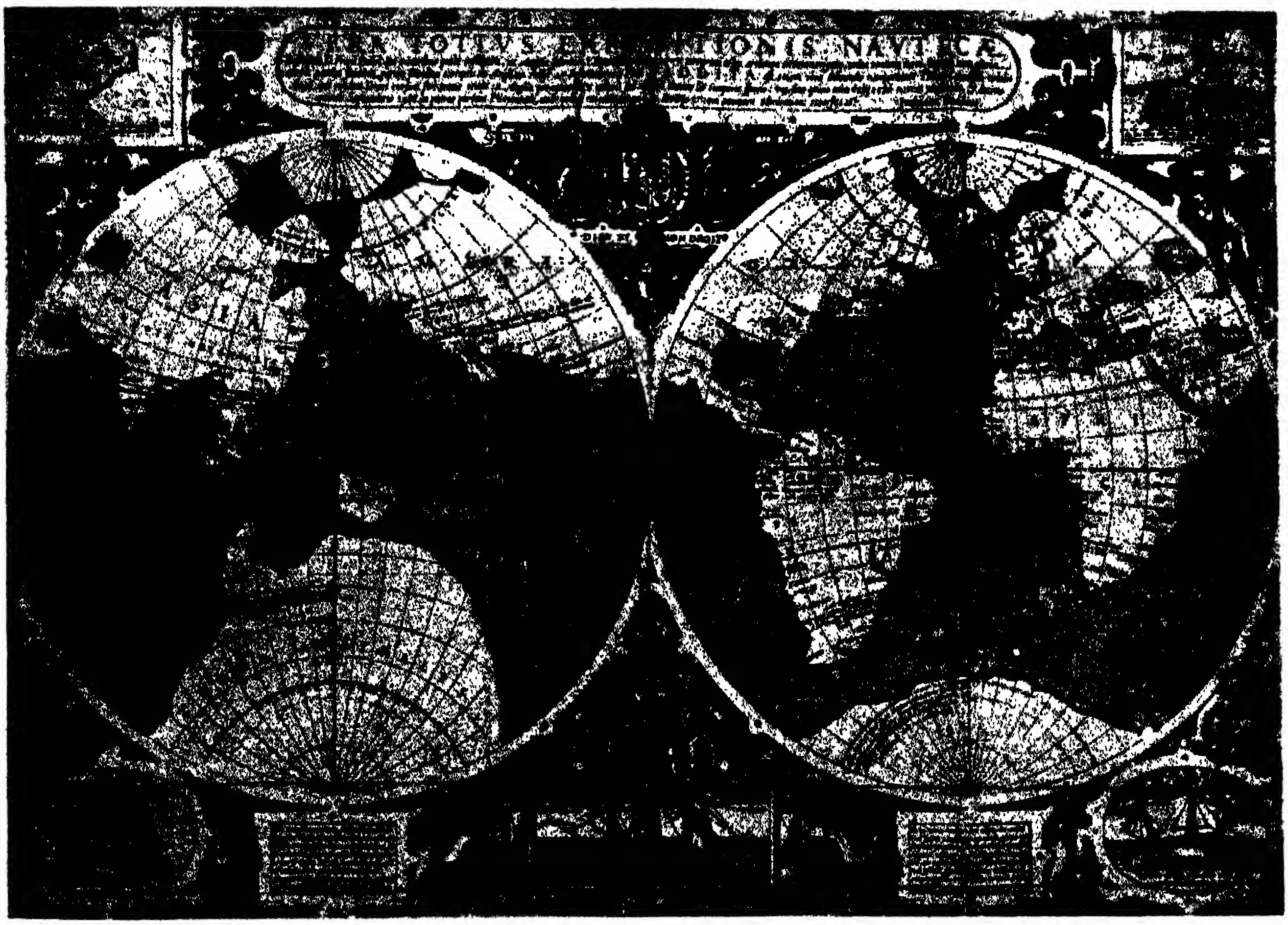
Holinshed, the old chronicler, tells us that "It were to be wished that in memory of this gentleman's incomparable achievement some monument might remain to succeeding ages and none more fitted than the brittle barque wherein he arrived safe and sound, which as a knight of good account and rarely qualified, thought meet to be fixed upon the stump of St. Paul's steeple in lieu of the spire that being discerned far and near it might be noted and pointed at of people with these true terms: Yonder is the barque that hath sailed round about the world."

The spire of St. Paul's Cathedral had some years before been destroyed by fire. It would certainly have been a novel monument to Drake's prowess if his little ship had been placed upon the tower of the cathedral.

Later the ship was broken up, but a chair made from its timber is to be seen in the Bodleian Library at Oxford, and in honour of the occasion the poet Abraham Cowley wrote the following lines:

> To this great ship which round the globe has run,
> And match'd in race the chariot of the sun;
> This Pythagorean ship (for it may claim,
> Without presumption so deserv'd a name),
> By knowledge, once and transformation now,
> In her new shape, this sacred port allow.
> Drake and his ship could not have wish'd from fate
> An happier station or more blest estate.
> For lo! a seat of endless rest is given
> To her in Oxford, and to him in heaven

It is said that Shakespeare obtained some of his ideas of strange and foreign parts, embodied in The Tempest, from the account of Drake's voyage round the world.



A contemporary map of the world by Hondius showing Drake's route from Plymouth, across the Atlantic, round South America, over the Pacific, and back to England again. Between the two halves of the globe, at the bottom, his ship the Golden Hind

A WORK OF MAN THAT RIVALS NATURE

Man's work seems that of a pigmy when compared with the gigantic monuments erected by Nature. Compare, for example, the Great Pyramid, the biggest thing of its kind, with Mount Everest, or the Panama Canal with the River Amazon. The greatest single thing, for size, that man has ever constructed is the Great Wall of China, which still exists and which the Chinese Government has proposed to turn into a motor road. It is over 1,400 miles long—that is, it stretches more than twice as far as from Land's End to John o' Groats—and is 25 feet wide at the base and 15 feet on top. Its height varies from 15 to 30 feet, and at every 200 yards there is a tower 40 or 50 feet high. It was built by the Chinese Emperor Shih-Hwang-ti about 200 years before Jesus was born, to keep out the Tartar raiders, but failed in its purpose. It certainly rivals a work of Nature

THE TORNADO THAT CUTS LIKE A SCYTHE

Severe and destructive storms occur from time to time in England. But it is in North America that the fiercest and most devastating storms are experienced. These are called tornadoes, and on this page we read many interesting things about them and the terrible damage they do to life and property.

It is curious that the most violent and destructive of all types of storm should at the same time be the smallest, that is, cover a less area than any other kind. The name for a destructive storm of this kind is tornado, a word which comes from the Spanish and means a turning, because of its rotary motion.

Tornadoes occur almost exclusively in the United States of America, although on a smaller scale they also occur in West Africa and one or two other areas. They are sometimes called cyclones, but that is an incorrect name.

A tornado travels at great speed and is invariably less than a minute in passing any given point. Its path is sometimes only a few feet wide, but at other times 2,000 feet, and while it may be only a mile in length, at other times the whirling hurricane travels over a course of two or three hundred miles.

It generally occurs between three and five in the afternoon, and a tornado is practically unknown between the hours of seven and nine in the morning. The most usual period of the year for tornadoes is from May to August inclusive, but in the Southern States of America they may occur at almost any time of the year.

The most distinctive thing about a tornado is a large black funnel-shaped cloud which extends downward from the dark clouds in the sky to very near the Earth surface. This whirls round as it travels, and wherever it passes it causes terrible devastation. Every year in the United States at least a hundred lives and a million pounds' worth of property are destroyed by tornadoes. From time to time still more violent storms of this kind occur, resulting in the loss of hundreds of lives and a vast amount of property.

Immediately before the approach of a tornado the clouds in the sky have a greenish-black appearance and seem to rush together and whirl about at great speed. Then in a moment the black funnel cloud appears and reaches down to the Earth. At times it widens out below, giving the appearance of an hour-glass.

It sways from side to side as though writhing and twisting, and slides along, cutting down everything in its way. Sometimes it gives a jump and misses the Earth for a short distance, only to come down again and continue its fell work. Trees are stripped of their branches and snapped off near the ground or torn up by the root. Brick and stone buildings are dashed to the ground like card houses, and trains and even heavy locomotives are blown from the railway tracks.

Such is the force of the wind in a tornado that straws have been driven like nails through boards, thin laths through trees, and wooden sticks through iron roofs.

Sometimes when the funnel cloud hits a building it causes a vacuum all round, and the air inside the building presses all the walls outward, so that the building seems to explode from the inside.

A tornado is always accompanied by a terrific roaring noise like the rushing of hundreds of express trains through a tunnel. So great is this that the crash of buildings is lost in the general roar.

The funnel-like cloud rotates about its centre at speeds of between a hundred miles and five hundred miles an hour. The cloud always rotates in the opposite direction to the movement of the clock hands, anti-clockwise.

A tornado always accompanies a thunderstorm of wider area, and it is really believed to be a kind of eddy in the larger storm. The laws which govern the formation of tornadoes, however, are at present only dimly understood.

In areas where tornadoes are liable to occur buildings often have what is known as a cyclone cellar, that is, a place of refuge underground where people can hide while the tornado, which has been seen approaching from a distance, passes.

A series of four remarkable photographs showing the progress of a tornado in Nebraska. In the first picture we see the greenish-black clouds which generally precede the tornado, then in the second and third the formation of the whirling funnel that does most of the damage, and in the last picture the rush of this funnel-shaped cloud across the country at anything from one hundred to five hundred miles an hour

HOW MAN IS RIVALLING THE WORK OF NATURE

Nature is the most patient and persistent worker in the Universe. She never stops, and this is true of the sculpturing of the rocks and the changing of the face of the Earth. Nothing is too mighty for her to work upon, and eventually Mount Everest will have to give way and be brought low under the operation of wind and weather. But man is now trying to rival Nature as a sculptor, and on this page we see a comparison of his work and the work of Nature. On the left is a giant boulder perched on other boulders that have been broken from the mountains. The picture was taken at the Thunderbolt Caves in Queensland, Australia. On the right is a gigantic face of Washington, sculptured out of the solid granite at Mount Rushmore in South Dakota, U.S.A. Here on a cliff 3,000 feet long and 800 feet high are being sculptured the heads of four of America's most famous Presidents, together with an inscription carved in letters three feet deep, so that the inscription can be read three miles away. The sculpturing is done with dynamite and pneumatic tools

MOUNTAINS SCULPTURED BY NATURE AND MAN

Nature is an everlasting sculptor. She works with never-ceasing industry to fashion and shape the mountains and the rocks. Wherever there is a mountain or a steep cliff, water and ice and the roots of trees, or the expansion and contraction due to changes in the temperature, loosen the surface and break it up into fragments.

The fragments that fall are then broken up and worn down by sea or river, and as they are dashed against the cliffs they grind away the lower parts till the upper structure becomes top-heavy and falls in its turn. Even away from sea and river, in the dry, arid desert, mountains and other rock masses are constantly being sculptured into queer shapes by the everlasting sand blast that is carried against them, as the wind whirls the loose particles from the ground.

The mills of Nature may grind slowly, but their work is sure. We see some examples of her strange sculpturing on page 386; another is shown opposite. Wind and water and weather all take their part in fashioning the rocks, and nothing is too massive for nature to shape as she will. Mount Everest and its companions, towering five miles into the air, have all been shaped by Nature's tools.

What can man do in comparison? Very little, although now with modern tools and high explosives he can blast away the rock and change a skyline.

In the old days it was not easy to sculpture the rocks on a massive scale. The biggest sculptured monument of ancient times is, of course, the Sphinx. It is mostly hewn out of the solid rock and stands 66 feet high to the crown of the head, while the length from fore-paws to the root of the tail is 187 feet. Compared with this the Lion of Lucerne, sculptured out of the sandstone rock by the Danish sculptor Thorwaldsen, is a very small affair. The Lion is only 28 feet long.

But now man is at work rivalling Nature as a fashioner of the rocks. Away in South Dakota is a cliff 3,000 feet long and towering 800 feet into the air. It is known as Mount Rushmore, and has a vertical rugged wall with an area of 60 acres.

This great rock is not composed of sandstone or limestone, but is of hard granite, and a sculptor is now at work upon it fashioning the greatest carved monument that has ever been sculptured by man in the history of the world. The work was begun by Gutzon Borglum, and after his death in 1941 was continued by his son. From the vast granite cliff a wonderful memorial to four of America's most noted Presidents is being carved.

This photograph of the Mount Rushmore National Memorial in South Dakota, U.S.A., shows the finished heads of presidents Washington, Jefferson and Theodore Roosevelt. On the right is the nearly completed head of President Lincoln. The heads are in the proportion of men 465 feet tall. It is 60 feet from the top of Washington's head to the tip of his chin

There is an enormous relief of Washington, Jefferson, Lincoln and T. Roosevelt. The figures will be flanked by a great tablet giving a five-hundred-word history of the United States written by the late President Coolidge, and the letters will be three feet high.

The sculptor and his assistants drill small holes and then with dynamite blast away the face of the rock to the rough shape required. This drilling and blasting at Mount Rushmore has been brought to a fine art. So skilful is the sculptor that by means of dynamite he can shape out a nose to within an inch or two of the finished surface. Even an eyeball can be shaped by dynamite. The work of sculpturing the hard rock is then completed by means of pneumatic drills. The sculptor and his assistants are suspended over the edge of the cliff by special harness.

The work has been going on since 1928, and it is expected that the completion will take some years more. In one year about 12,000 cubic yards of granite are removed from the cliff face, and this is equal to 24,000 tons. Of course, when one remembers the primitive nature of the tools in ancient times the Sphinx is really a more stupendous work.

THE WONDERFUL PEG-TOP ROCK OF COLORADO

Here is a remarkable rock that stands in the desert of Colorado and looks like a gigantic peg-top balanced on its point The hot sunshine pouring down on rocks in dry climates overheats them and causes their surfaces to burst and break off The parts thus broken off become split into smaller fragments and these, carried by the wind against the rocks, wear away the surface This sand blast is denser near the ground and so wears away the lower part of an isolated rock more than the upper part, with the result that it is left shaped like a mushroom or peg-top One day, perhaps it may be centuries hence, the rock will come crashing down

THE ONLY WORK OF HUMAN HANDS THAT WOULD BE VISIBLE FROM THE MOON

The section of the Great Wall of China shown here is at the Nankow Pass, not far from Peking, and is one of the best-preserved stretches of this mighty work. Another part of the Wall is shown in page 556. The Great Wall, which extends across the north of the country from the borders of the Tibet in the west to the Gulf of Liau-tung near the Manchurian boundary in the east, took 14 years to build. Prisoners numbering 3½ million were employed on it and, when they proved unequal to the task, every third man in the Empire was commanded to join the labour force.

To face page 561

WONDERS OF THE SKY

WATCHING THE EARTH GO ROUND

We all believe that the Earth turns round on its axis once in every 24 hours. But what reason is there for believing this? We look up at night and see the heavens move round, and we see the Sun rise in the east and move across the sky, sinking in the west. But we should see these things in the same way if the Earth stood still and the heavens and the Sun really moved, as they appear to do. It is well that we should know the reasons men of science have for believing that it is the Earth itself that turns round. Here they are

When you get out among the fields and into the country or up on the hills, how very quiet and still everything seems, especially in the evening. Yet you and the fields and the trees are rushing through space at hundreds of miles an hour.

The Earth on which we live has many different motions. It is travelling round the Sun in its orbit at eighteen and a half miles a second, which is equal to over 66,000 miles an hour, and in company with the Sun and the rest of his family of planets, our globe is tearing through space in the direction of the star Vega at about 40,000 miles an hour.

But the motion of the Earth that makes the most difference to us is its rotation on its axis. Once in about every twenty-four hours it makes a complete turn, and it is this rotation of the Earth that gives us night and day and also gives us the impression that the Sun travels across the sky every day from east to west, and the whole heavens revolve above our heads.

The Sun's Apparent Journey

The Sun is seen to rise in the east, get slowly higher and higher in the heavens till it reaches its highest point, and then descend at the same rate till at last it sinks below the horizon on the opposite side. It is not surprising that with such an appearance the men of old who studied the heavens thought that the Sun did really travel in a path across the sky while the Earth, which seems so still, remained stationary.

Of course, we know better now. We know that it is the Earth that turns round on its axis and not the Sun that travels round the Earth.

It is not only the Sun that appears to move in the sky but even the stars. Those tiny twinkling points of light so far away which peep out of the darkness also appear to be moving. They all appear to be circling round a given point in the sky: the point that is very near to the star we call the Pole Star.

It is easy to find the Pole Star when we look up. We can all see that part of the Great Bear constellation which from its shape is called the Plough. Well, the two stars at one end point almost in a direct line to the Pole Star.

Now let us perform a simple and interesting experiment which will help us to understand something of the Earth's movement as it turns round on its axis. We take an old umbrella and open it, and on the inside we make little white dots to represent the stars of the Plough, placing them so that the point where the stick goes through the cloth will represent the Pole Star. If we now hold the umbrella over our head with the ferrule pointing at the Pole Star in the sky and the Plough marked on the inside of the umbrella corresponding with the actual stars of the Plough above us we shall have on the inside of the umbrella a representation of the heavens. We can make this more realistic and interesting by drawing in some other prominent stars.

Now, keeping the umbrella pointed towards the Pole Star, let us turn it round slowly in our hand. We shall see that the white dots we have made to represent the stars of the Plough and the other stars all move round. That is the kind of movement we seem to see as we look up at the sky.

Have you ever thought that when you watch the Sun sinking below the horizon, you are not really watching the Sun move at all, but are seeing the Earth rotate? The horizon is rising as the Earth turns and is coming up above the Sun

An Umbrella Experiment

But now fix the umbrella in the required position and instead of turning it round, let it remain stationary and you yourself move round underneath it, looking up into it as you do so. You will find that the stars you drew on the inside of the umbrella change their positions relative to yourself as you move in exactly the same way as they did when you turned the umbrella round. Of course, in moving round under the stationary umbrella you must move in an opposite direction from that in which you turned the umbrella in order to get the same effect.

Now this experiment has taught us an interesting and important lesson. The effect is the same, so far as what we see is concerned, whether we stand still ourselves and turn the umbrella round, or whether we keep the umbrella still and turn round ourselves in the opposite direction.

When the whole sky appears to be turning round over our heads one of two things must be happening. Either all the stars are rushing round in a certain direction or they are stationary relative to the

Earth and we and the Earth are rushing round in the opposite direction. Which is the true solution of the puzzle?

Well, we know now what people of old did not know, that it is the Earth that turns round on its axis and not the whole heavens which revolve round a stationary Earth.

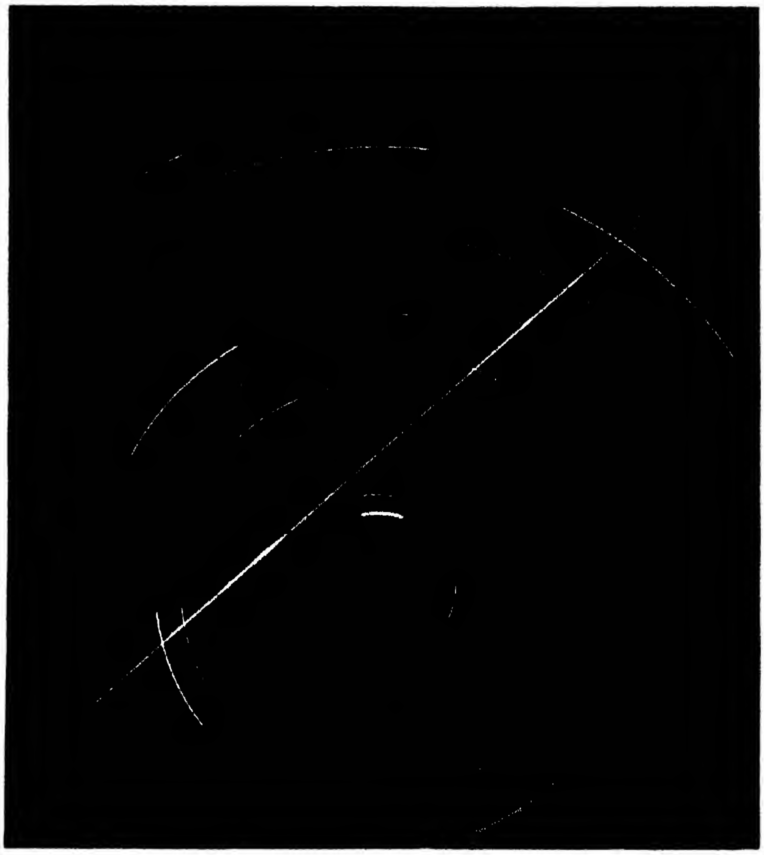
But even in the old days the idea of a rotating Earth was suggested, though there was no scientific evidence to support such a theory. A Greek named Philolaus, who lived in the fifth century before Christ, conceived the idea that the Earth turned round as well as the Sun, the Moon, and all the planets.

Early Ideas

He thought they revolved about a great central fire, the Earth turning on an axis as it revolved, so that the central fire for ever remained hidden from the Earth's inhabitants.

But no one really believed this. They thought the heavens must move round a stationary Earth. Even the great Egyptian astronomer and geographer Ptolemy, who flourished at Alexandria about a century and a half after Christ, could not believe it possible that the Earth turned round, although he realised that such a rotation would account for the alternation of day and night and the apparent movement of the heavens.

It is interesting to know his arguments against the rotation of the Earth. If, said Ptolemy, the Earth turns round on its axis, then places at the Equator must move with a speed of nearly a thousand miles an hour. Of course, in these days we know that places at the Equator do move at this speed, but Ptolemy said this speed is ten times that of the wind in the severest storm, and so if the Earth rotated on its axis there would always be a terrible gale blowing from the east. Birds in flight and objects thrown up into the air would be left behind and carried with terrific speed towards the west. These things do not happen, and so, said Ptolemy, the Earth cannot be turning round on its axis, but must be at rest. Of course the explanation is that the atmosphere, held by gravitation, is part of the Earth and goes round with it.

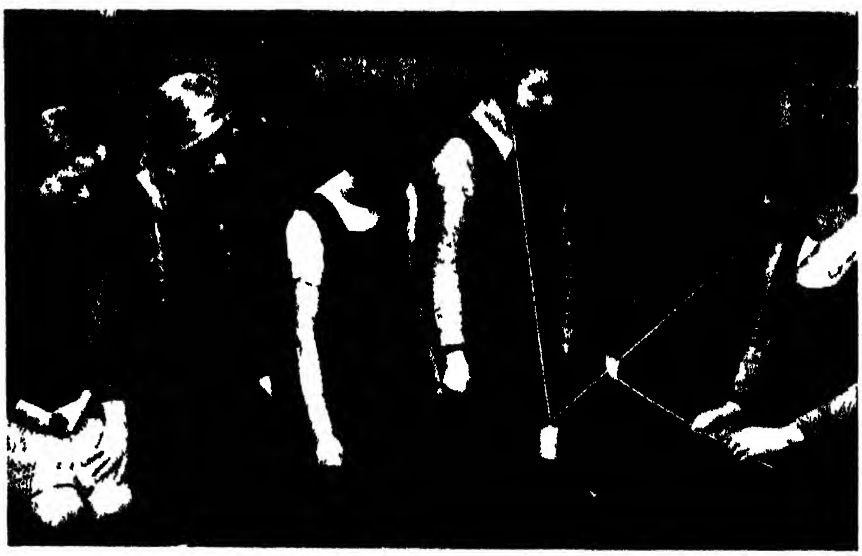


This photograph, published by courtesy of the Norman Lockyer Observatory, shows the heavens round the Pole Star. It was given an exposure of 2½ hours and the stars appear not as points of light but as curved lines, because as the Earth turned on its axis the heavens appeared to be moving in the opposite direction. This is one of the proofs of the Earth's rotation. The diagonal line was the passage of a meteor across the sky while the plate was being exposed.

It was not until fourteen centuries later, that is the year 1543, that another great astronomer, Copernicus, a German born in Poland, taught that the Earth turned round every twenty-four hours.

The Real Facts

He showed in a great book which he wrote that a rotating Earth explained the rising and setting of the stars much more simply than did the theories of Ptolemy. He recognised that all the phenomena of the heavens could be explained by either theory, that is, by the theory that the stars are attached to a great celestial globe which turns about an axis, or by the fact that the stars are stationary and that it is the Earth that turns round upon its axis. But Copernicus could not prove that the Earth rotates. At that time there was not sufficient knowledge, nor were there available instruments to give the necessary proofs. But from the time of Copernicus it was accepted by practically all men of science that it was the Earth that turned round and not the heavens.



Girls at a Stoke-on-Trent school about to repeat Foucault's pendulum experiment to show the Earth's rotation. They are burning the cotton to release the pendulum and set it swinging in a perfectly regular and even manner.

It is less than a hundred years ago that the first real proof of the Earth's rotation was obtained, and this resulted from an interesting experiment which a great French physicist, Jean Foucault, carried out in the Pantheon at Paris. He used a great pendulum to show that the Earth rotated. The ordinary pendulum of a

clock is supported on knife edges or on pivots, and it is able to swing only in one plane, that is in one direction relative to the clock. It swings to and fro always in this direction, and if we tried to swing it at right angles to the way it normally swings, it would soon stop.

Now Foucault made a pendulum which should be free to swing in any direction. He fastened a heavy iron ball a foot in diameter to a thin flexible wire and then supported this wire at the upper end in the dome of the Panthéon. The wire was 200 feet long, probably the longest pendulum that had ever been made.

On the bottom of the iron ball which formed the bob of the pendulum he fixed a sharp, steel point, and then he placed underneath this a circular table about 12 feet in diameter. On this table Foucault strewed a quantity of very fine sand, and he arranged the table in such a position beneath the bob of the pendulum that when the pendulum swung from side to side the point would just touch the sand and leave a little mark on the surface as it went to and fro.

The Swinging Chain

Now before we go on with the story of Foucault and his pendulum which proved that the Earth turns round on its axis, we can ourselves carry out a little experiment which will help us to understand what happened in the Panthéon.

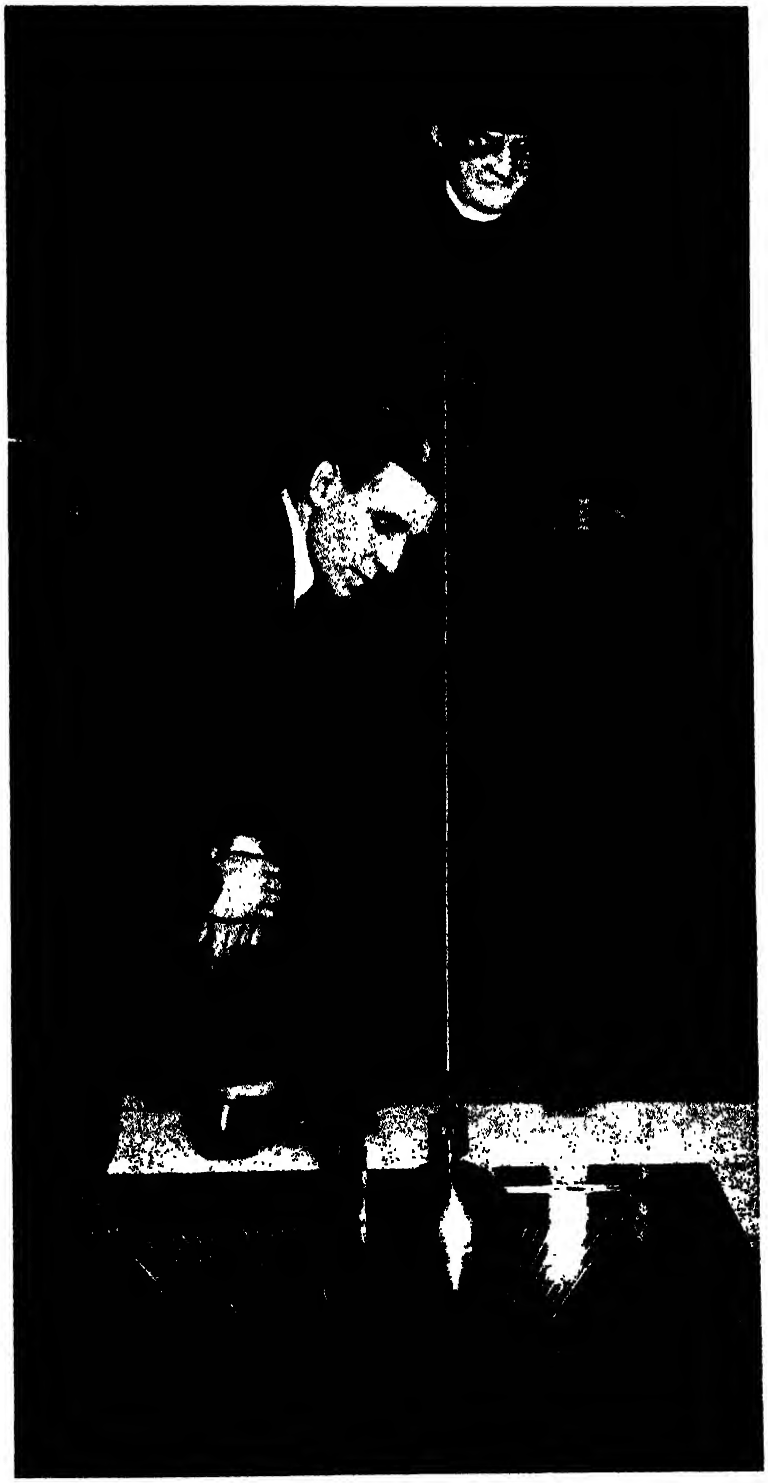
Take a chain, such as a watch-chain, which has a swivel joint at one end. Hang this chain up by the hook which usually holds the watch, and then on the other end, where the swivel is, suspend a small weight. Start the whole thing swinging so that the weight and the chain can form a pendulum. As this swings, slowly turn the hook by which it is suspended and you will find that the direction of the swing does not change as you turn. The weight and chain will go on swinging in the same direction in which they started.

We learn from this a very important fact about a pendulum, and that is that once it has started swinging it resists all attempts to make it swing in a different direction.

Now it was this fact which Foucault used to prove the rotation of the Earth. He reasoned that if a great pendulum were set swinging in a certain direction and that it was so suspended that it could turn in any direction, it would go on swinging in the direction in which it was started, although the Earth or that part of the Earth (in this case the Panthéon dome) to which it was attached, went on rotating.

It was necessary, of course, that the pendulum should be set swinging in the first place very steadily without any jarring movement, and in order that this might be assured he drew the pendulum to one side and held it in place by a string. It was left for several hours till it became absolutely at rest, and then Foucault burned the string, and the pendulum, without any jerk, started to swing to and fro.

All these precautions were necessary if the pendulum were to be started swinging in an absolutely true plane, which was necessary for the success of the experiment. Of course, a long pendulum, like that which was suspended in the Panthéon, takes a long time for its to-and-fro motion.



A large pendulum at the Science Museum in Kensington, which by its swinging showed that the Earth was turning round on its axis

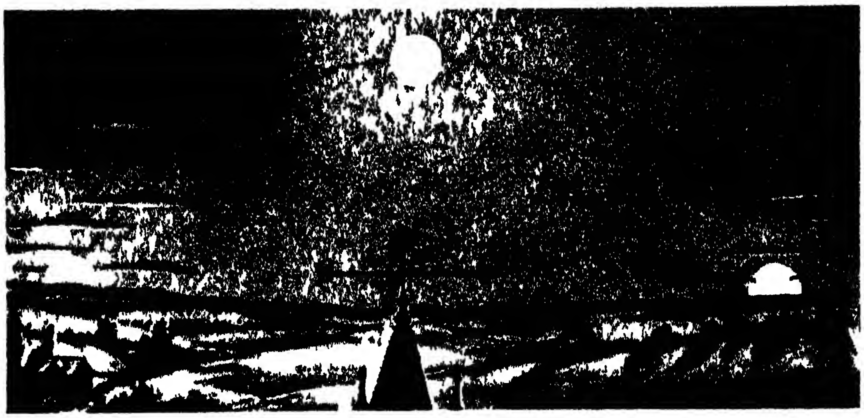
The Pendulum's Swing

As it went down and across the sand for the first time the point underneath the bob marked a straight line on the surface of the sand. When the pendulum swung back, however, the mark made by the point was in a slightly different direction. It was clear, after a very short time, that the plane in which the pendulum was swinging was apparently moving round toward the right. And so it went on; the direction of the pendulum seemed to change relative to the building in which it was swinging, but actually it did not change. It went on swinging in the same plane while the building and the Earth turned round.

The experiment was carried out again and again, and always there was the same result. The swing of the pendulum appeared to shift towards the right, and it always changed the same amount in the same period of time.

The only possible explanation of this was that the floor of the Pantheon was really turning underneath the swinging pendulum.

The experiment has been carried out many times since, and is sometimes done in schools. It was performed at the Polytechnic in Regent Street, London, with a pendulum 15 feet long and a bob weighing 28 pounds, while in Cologne Cathedral it was performed with a pendulum 132 feet long. More recently an experiment was carried out at the Science Museum in Kensington.



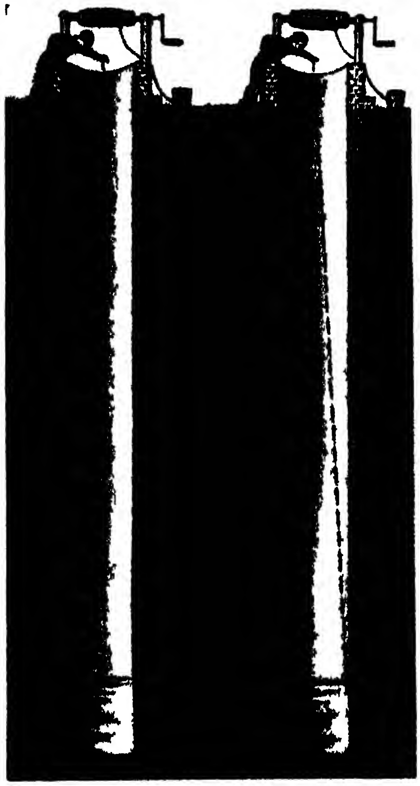
The Sun's apparent passage across the heavens, due to the rotation of the Earth

What the Pendulum Proves

If such a pendulum could be erected on the North or South Pole and set swinging it would appear to an observer to turn slowly in the direction of the hand of a watch at the rate of 15 degrees per hour, so that the plane of rotation would turn through a complete circle in twenty-four hours. At other places on the Earth's surface the rate of change varies, and the farther from the Poles and the nearer to the Equator the pendulum is set up the less rapid is the change. In latitude 54, which cuts across England from York to Morecambe Bay, for instance, a complete circle would be described by the pendulum in about 28 hours, while in latitude 5, which goes from Cape Coast on the Gold Coast, the pendulum would take about 11 days to make a complete circle. The reason for this is too technical to explain here.

The behaviour of the pendulum therefore is one of the proofs that the Earth on which we live is turning round on its axis.

Another proof is that the stars could not exist if the Earth were stationary and the heavens were rushing round. We can of course only know this now that we understand how very far off the stars are. They are millions of millions of miles away, and if they were rushing round the Earth every 24 hours at that distance their speed would have to be so terrific that they would be all smashed up by centrifugal force, just as a fly-wheel if it goes round too quickly will be broken by the same force, its parts being hurled in all directions. That is another proof that it cannot be the heavens which are moving round.



The deflection of a stone dropped down a well, which proves that the Earth is rotating

Another proof that the Earth is turning round can be obtained by an experiment which has often been carried out. If a metal ball is dropped from the top of a deep well or mine to the bottom it is found that it falls slightly to the eastward, and this can only be due to the motion of the Earth from west to east, as we shall see.

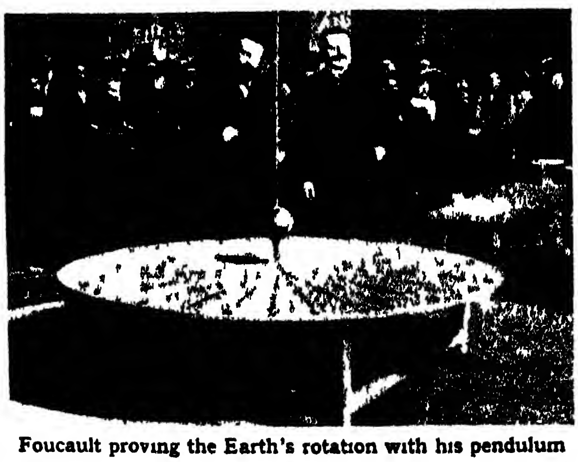
When small and perfectly round balls were dropped with very great care down deep mines it was found by careful measurements that they struck the bottom a little to the east of the point which was vertically under their starting point. Now the top of the mine is farther from the centre of the Earth than the bottom, and so is moving faster towards the east than the bottom of the mine.

Dropping a Stone Down a Mine

A body therefore dropped from the mouth of the mine has the speed at which the surface of the Earth is moving. It keeps this speed as it falls, and so strikes the bottom of the mine a little in advance of the point on which it would have fallen if the Earth had been still. It has been found after many experiments that a body falling 520 feet deviates more than an inch to the east.

Still another proof that the Earth rotates is provided by the fact that projectiles when fired from guns always deviate to the right in the Northern Hemisphere and to the left in the Southern. The great ocean currents and winds like the trades and anti-trades are all deflected by the rotation of the Earth. They would not move in the slanting direction that they do if the Earth stood still and it was the heavens above that rotated.

Also by very technical experiments the rotation of the Earth can be proved by the action of the Gyroscope, but that is too difficult to go into here.



Foucault proving the Earth's rotation with his pendulum

We can also reason that the Earth rotates on its axis by the fact which the telescope has revealed, that all the other heavenly bodies of which we can get any knowledge at all appear to rotate. The Moon, the Sun, the various planets and their satellites all turn round on their axes in given periods, and it would be incredible that the Earth, which is one of the planets and whose satellite itself rotates, should prove an exception. It is an argument from analogy, but it is quite a good one. When we take all these various facts into consideration there can be no doubt whatever that the Earth on which we live rotates on its axis in about 24 hours.

A CURIOUS PROPERTY OF ALL MATTER

Inertia may seem a forbidding scientific word, but whether we like the word or not, we cannot get away from the fact of inertia, which is simply the universal property possessed by all matter of being unable to change its own state of motion or rest. Inertia comes into all our lives every hour of the day, and here we read something about it and what it means to us in work and play

HAVE you ever considered why, when you put a book on the table or a chair on the floor it remains there till someone moves it? And has it ever struck you as curious that when you throw a ball, the ball goes on moving after it has left your hand?

Well, in both cases the reason is the same. All matter has a property which is known as Inertia. The word means inactive, and when we say matter is inert, we mean that it cannot of itself start or stop or change the direction of its motion. If a body is at rest, as when you lay the book on the table, then it will remain so for ever unless some outside force sets it in motion. If, on the other hand, a body is set in motion as when you throw the ball, then it will go on in a straight line for ever unless something stops it or turns it out of its course.

This property of inertia comes into our lives every hour of the day and affects us in a thousand ways. If we jump off a vehicle such as a bus or tramcar while it is still in motion—a very foolish thing to do—we shall be thrown down unless after reaching the ground we run forward a few steps to give our body, which has the vehicle's motion, time to slow down. The upper part of our body continues its motion, and unless we run forward our feet are prevented from moving by the friction of the ground.

When a train in which we are travelling stops suddenly we are thrown forward if we are facing the engine, and if a stationary train in which we are sitting starts suddenly we are thrown backward. In one case our body which has the train's motion, tends through inertia, to continue going forward, while in the other case our stationary body, tends to remain still, till the carriage takes us forward.

When we strike the end of a hammer handle on the ground to force the head at the other end on more tightly, we are using inertia. The handle, as we bring down the hammer, is suddenly stopped by the ground, but the hammer head tends to go on moving downward and so is forced farther on to the handle.

Many other examples of the use or experience of inertia, in our daily lives, are shown in the pictures on these pages. When we shake the water from an overcoat on a wet day, or beat a carpet, or kick a football, we are using inertia, and even the animals make use of it as when a dog shakes himself after coming out of a river or pond.

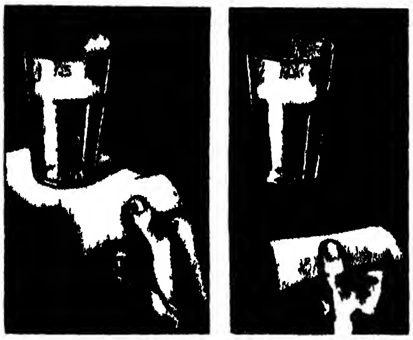
No matter what we do we cannot get away from this property of matter which is ever with us.

When the washerwoman shakes the wet clothes to free them of as much water as possible before hanging them on the clothes-line to dry, and when a carpet is shaken or beaten to free it of dust, the property of inertia is being put to practical use. Clothes or carpets are shaken out and then drawn back suddenly, so that the motion given to the water or dust in them may continue, thus hurling out the water or dust as the cloth is drawn back. In beating a carpet, motion forward is given to the loose particles of dust, which are thus hurled forward out of the carpet, that article remaining behind on the clothes-line

EXPERIMENTS THAT ILLUSTRATE INERTIA

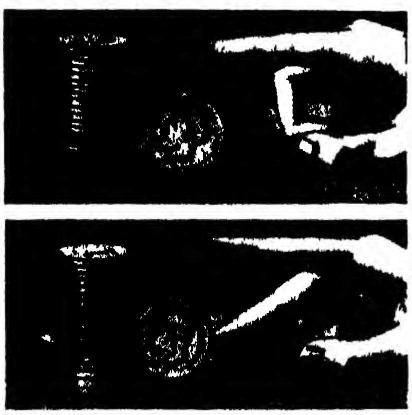
There are many interesting experiments which we can perform at home or at school to illustrate the property of inertia. Here is one. Stand a tumbler which is about three quarters full of water on a sheet of smooth paper lying on a polished table. The paper and glass should be near the edge of the table as shown in the picture.

Now, taking hold of the edge of the paper with a firm grip and moving the hand a little towards the glass so as to



The paper, if flicked away quickly, will not displace the tumbler

bend the paper slightly, suddenly jerk the paper from under the glass, taking care to keep your hand near the level of the table. If you jerk quickly enough the paper will come away and the glass remain upright on the table without any water being spilt. The



A flick of the finger against the standing coin will drive out the projecting penny without upsetting the pile

inertia of rest causes the glass to remain still because with so rapid a jerk the motion of the paper is not communicated to the tumbler.

Let us try another experiment. In this case we stand a pile of about twenty pennies on the table, stacking them neatly one above another with one, say the sixth up, projecting a little towards where we are standing.

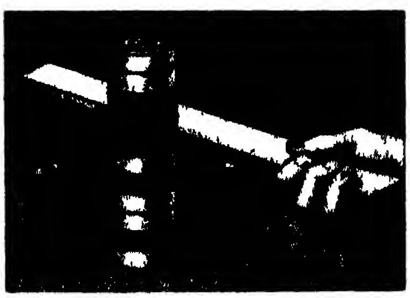
Now support another penny on its edge so that it touches the projecting penny. With the middle finger and thumb flick the upright penny sharply and firmly and if we have caught it fairly about the middle it will be thrust against the projecting coin with such force as to shoot that coin out on the far side and the pile will not be knocked over or disarranged.

By bringing our hand down rapidly we can catch the pile of coins before it falls

Here again the inertia of rest causes the pile to remain, the motion of the moving coin not having been communicated to the others owing to its rapidity. Fairly new unworn pennies of more or less uniform thickness should be used.

A somewhat similar experiment can be performed with a pile of men used in the game of draughts. When they are neatly in position we take a ruler and selecting one of the men give it a short sharp rapid blow with the ruler. It will be knocked out of the pile but the men stacked above it will remain in position merely descending upon the next draught.

Here is an experiment which can be performed at a party, others present being challenged to try it. We raise our bended arm so that the upper part is horizontal and then as near the elbow as possible we place a stack of pennies—five or six is a suitable number. Now we declare we are going to lower our arm and catch the coins before they fall.



A sharp tap against one of the draughts will drive it from the pile

It is done by moving the hand forward very rapidly and steadily. Inertia causes the pennies to remain stacked up after our elbow is lowered, just long enough for us to catch them in our hand. But we must be very quick in our movement.

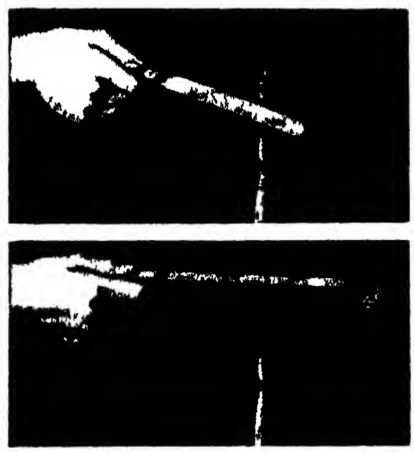
The experiment with the tumbler of water and the sheet of paper can be performed with a coin instead of the glass. Stand on the paper a penny or half crown as shown in the picture, and then with a rapid jerk pull the paper away. The coin will remain on the table and if we are careful will not fall over. A new half crown is the easiest coin to stand on its edge.

Another experiment to illustrate inertia can be carried out with a bottle, a cork and a pea or other particle. Stand the cork upside down, on the bottle, and on the top of the

A rapid flick will draw the paper away without knocking over the coin

cork immediately over the opening, place the pea.

Now with a knife or ruler give a sharp tap so as to send the cork flying. The pea will not receive the motion



A sharp blow against the cork with the edge of the knife will send it flying and the pea will drop into the bottle

of the cork and so will remain behind and fall into the open mouth of the bottle.

All of these experiments are examples of the inertia of rest. An example of the inertia of movement is seen when a boy sets off on roller skates over a level surface. If he does not sway his body and keeps his feet together he will go on in a straight line unless someone gives him a push when his course will be changed to another direction.

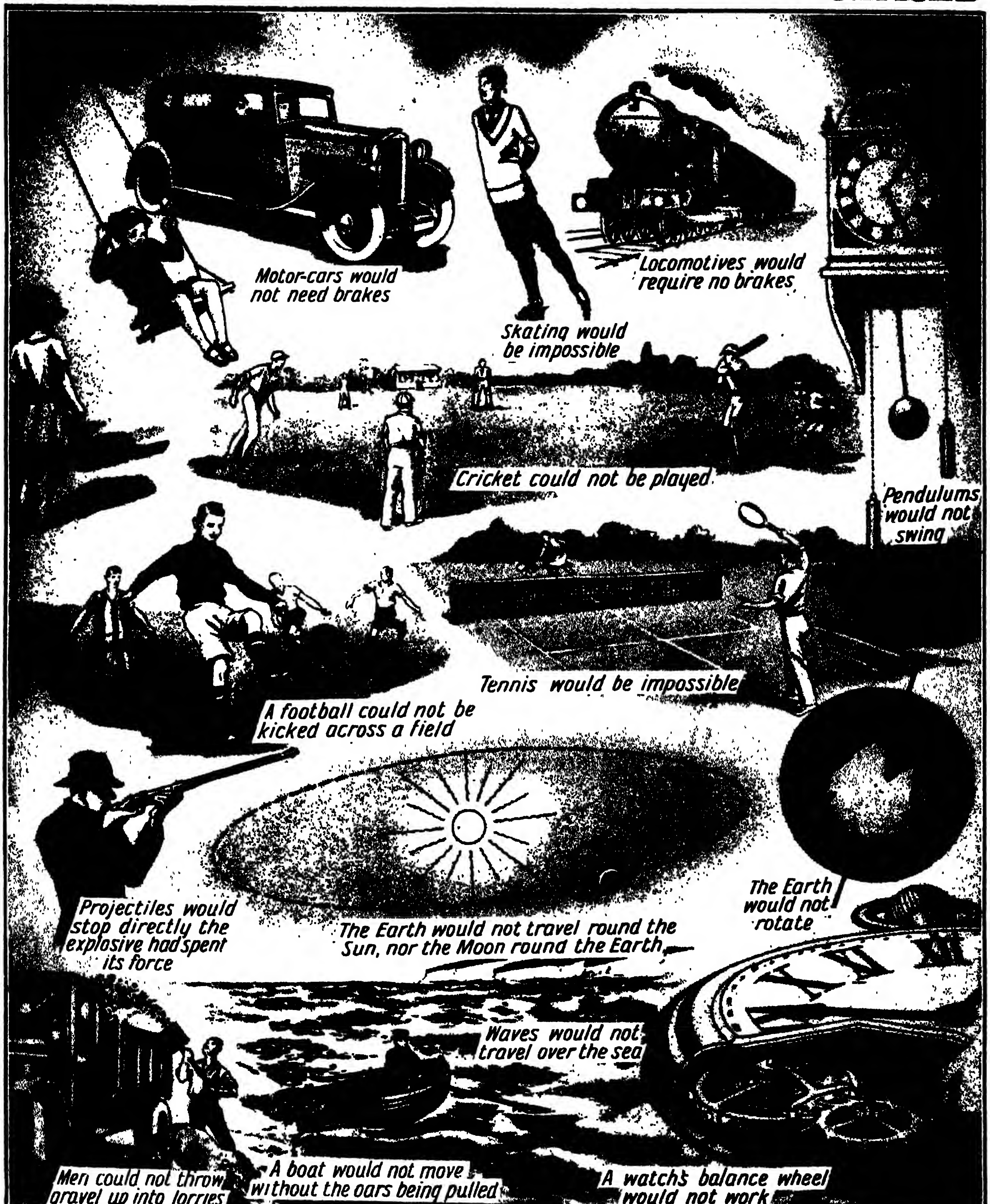
SOME FAMILIAR EXAMPLES OF INERTIA

When we are travelling in a motor-car or train which suddenly pulls up we are thrown in the direction in which the vehicle is going. This is due to inertia, by which a moving body, unless stopped by some outside force, will go on moving in a straight line. When the car is stopped suddenly our bodies, having acquired its motion, continue moving forward. When the car or train starts suddenly we are thrown in the opposite direction, because by the law of inertia a body that is at rest tends to remain so till something sets it in motion

When a dog coming out of the water shakes himself to get rid of the wet, he is observing the law of inertia. His violent shaking gives motion to the drops of water on his coat, which are thrown off in all directions, while his body remains stationary

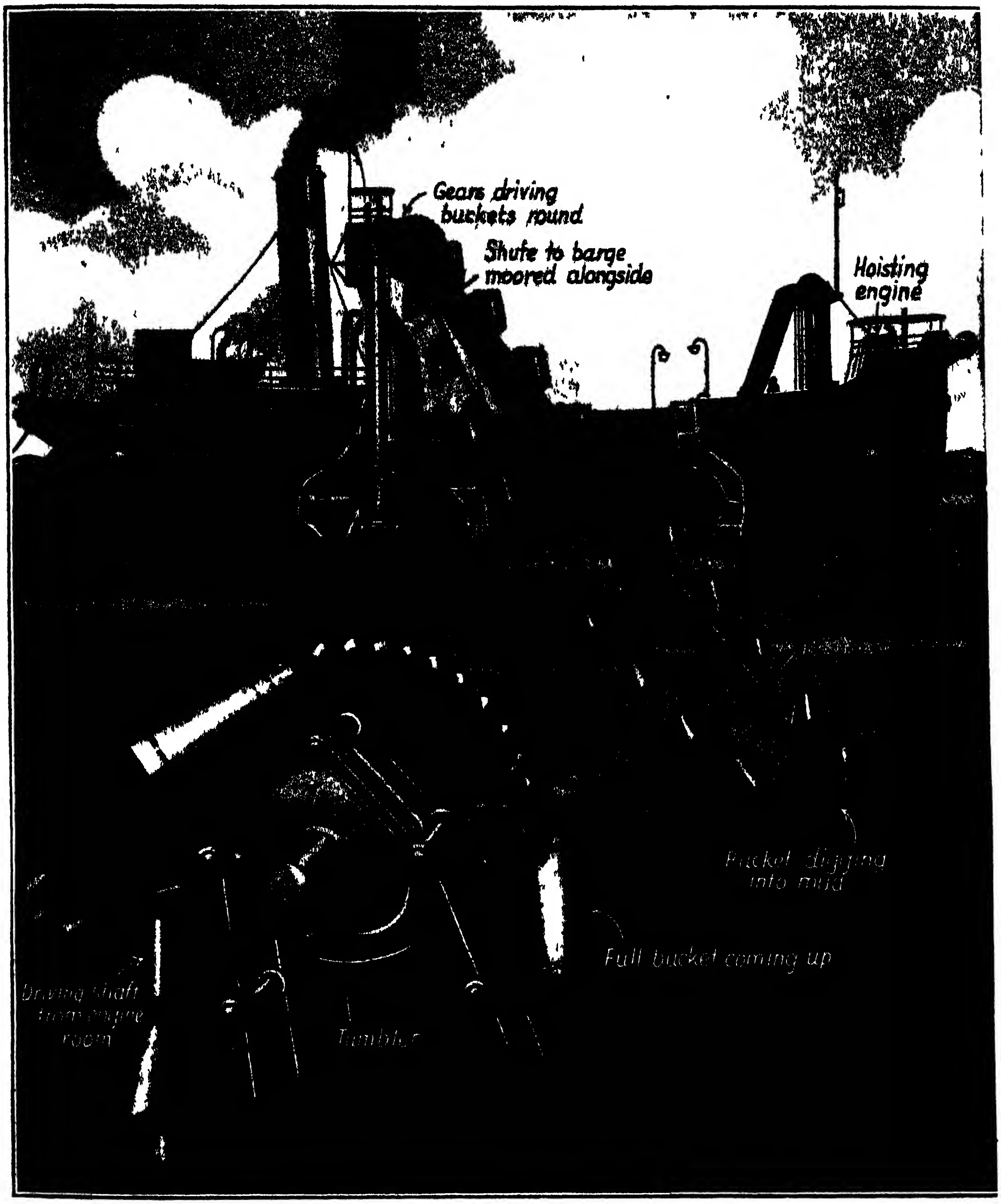
A person who jumps off a moving bus must step off with the left foot and incline his body back, as in the first picture, to counteract the motion from the bus. He must also run a few steps so that the friction of the ground may not act as a brake on his feet. Otherwise the feet remain on the ground, while the body is thrown violently backwards, as on the right, by the motion from the bus

WHAT WOULD HAPPEN IF INERTIA CEASED



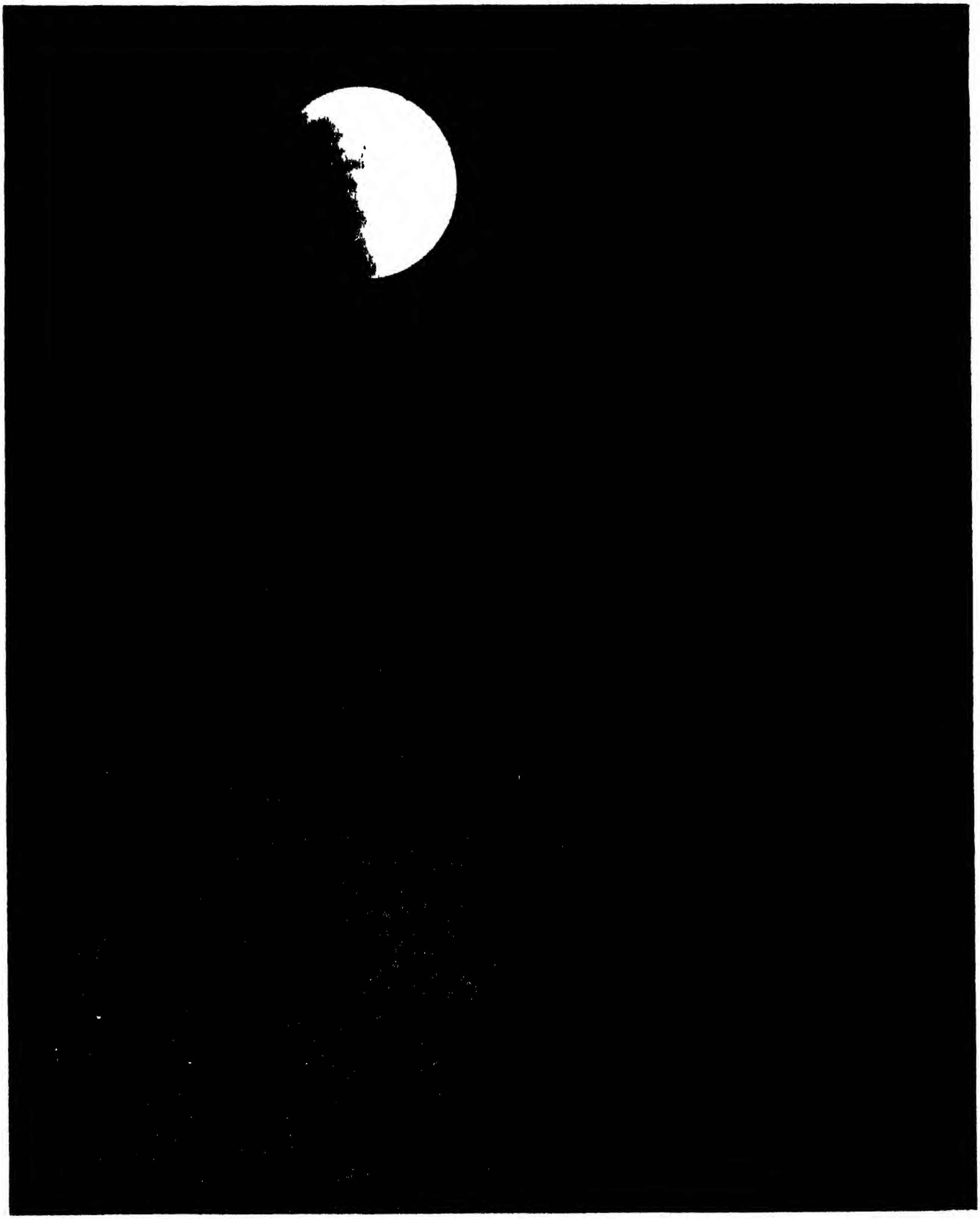
The pictures on this page suggest some of the strange things that would happen if inertia suddenly ceased. Vehicles would not need brakes ; they would stop dead directly the engine was shut off. Ball games could not be played, for directly the hand or foot or bat or racket ceased to touch the ball it would drop vertically to the ground. Bullets would get no impetus, but would fall directly the actual push of the explosive ceased. Pendulums would not swing nor balance wheels work. Waves would not travel, nor rowing boats move forward when the oars were raised for another pull. The Earth and other heavenly bodies would cease to travel in their orbits or rotate on their axes, for the impulse of movement they received millions of years ago would cease to operate. Skating and sliding and swinging and other movements set going and continued by a push would be quite impossible

HOW A BUCKET DREDGER SCOOPS OUT CHANNELS



In this picture we see how the bucket ladder dredger works. There is a continuous chain of buckets running round a rigid frame called the ladder, which is lowered to the sea bed or river bottom. The machinery is set working, and the buckets go down empty on the under side of the ladder, dig into the mud or sand at the bottom, and then run round the end of the ladder and return full on the upper side. On reaching the top end the buckets are taken round a square tumbler or rotating frame, shown enlarged in the bottom left-hand drawing This is driven by a shaft from the engine-room of the dredger. As the buckets turn over they empty their contents into a shute which conveys the matter to a barge moored alongside. The forward end of the dredger-boat is cut away in the centre, forming a well, so as to allow the dredger arm to be lowered and raised by means of wire ropes and tackle supported by a strong iron frame. The photograph on page 704 shows another arrangement in which the ladder of buckets is lowered through the stern of the dredger

AN ECLIPSE OF THE MOON AS SEEN FROM LONDON



This remarkably clear photograph showing a partial eclipse of the Moon was taken in London on September 14th, 1932. In the photograph appears the ball and cross of St. Paul's Cathedral silhouetted against the night sky. This particular eclipse, which was visible from Europe, Africa, Asia and Australia, began at five minutes past six, and at nine o'clock the greatest area of the Moon's disc was in shadow. Then the shadow began to pass off, and the eclipse ended four minutes before midnight. An eclipse of the Moon differs from an eclipse of the Sun in that what we see is a shadow passing across the Moon and not an actual object as when the Móon itself gets between us and the Sun and darkens the Sun's face. This photograph was taken with a telescopic camera

HOW AN ECLIPSE OF THE MOON IS CAUSED

A partial or total eclipse of the Moon is a fairly familiar sight, and we all ought to know exactly what the dark shadow is that crosses the Moon's face and how the eclipse is caused. In these pages we read many interesting facts which will help us to understand a lunar eclipse.

An eclipse of the Moon is a far more familiar sight than an eclipse of the Sun. We all get an opportunity of seeing a lunar eclipse more frequently than we do a solar eclipse. This seems curious because there are more eclipses of the Sun than of the Moon. Actually there are about four eclipses of the Sun to three of the Moon. Yet the former are seen at any particular place, such for example as London or Birmingham or Edinburgh, much less frequently than the lunar eclipses.

The reason is simple. An eclipse of the Moon is always visible from more than half of the Earth's surface, and an observer at any particular place may on an average see rather more than half of the lunar eclipses that occur.

Eclipses of the Sun on the other hand are visible from only a very small part of the Earth's surface, and an observer does not see them unless he happens to be in their path.

Now the path of a total eclipse of the Sun is generally less than a hundred miles wide on the Earth's surface, and a few thousand miles long. Even the path over which a partial eclipse of the Sun is seen is usually only four or five thousand miles wide. It is clear therefore that the path of a total eclipse strikes any given place on the Earth very rarely indeed. We know how rarely a total eclipse is seen in England by the excitement that there was over the total eclipse of June 29th, 1927, the first for very many years to be visible in England.

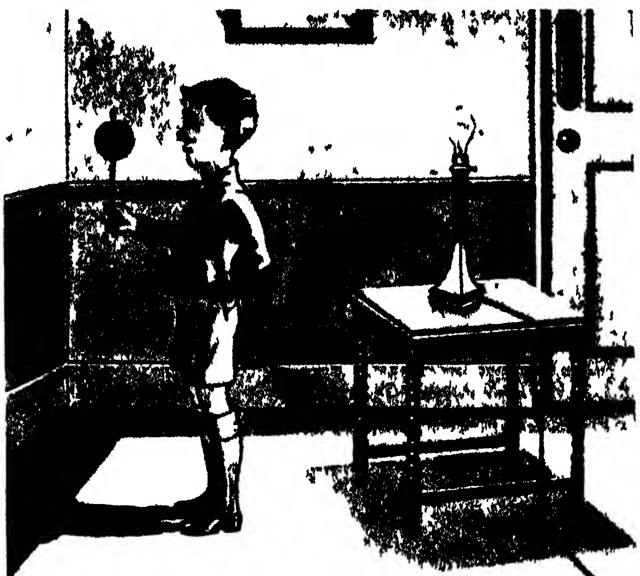
As we see on page 227, an eclipse of the Sun is caused by the Moon getting in between the Earth and the Sun and blotting out the Sun's light. The dark disc which we see cross the Sun's face is not a shadow but the actual Moon itself.

But an eclipse of the Moon is caused in a different way. Here the darkness that crosses the Moon's disc is not an actual body, but the shadow of the Earth which passes between the Sun and the Moon. In other words, the Moon enters the shadow which the Earth casts into Space.

Here it will be interesting to think a little about this shadow which the Earth casts on the opposite side from that on which the Sun shines. This shadow is not a mere surface like the shadow of our head upon the wall when we get between the wall and the electric lamp. It is, from a geometrical point of view, not a surface but a solid shape, and is really a cone of shadow.

This shadow cast by the Earth away into Space is about 857,000 miles long. It varies to the extent of about 14,000 miles on each side of this figure, owing to the variation of the Earth's distance from the Sun at different times of the year; that is, sometimes the shadow is 871,000 miles long and sometimes only 843,000 miles.

In addition to the cone-shaped dark shadow, or umbra, as it is called, there is a cone-shaped penumbra, or part shadow. This is explained in the picture of the umbra and penumbra on page 228.



This boy is performing a simple experiment that shows how an eclipse of the Moon is caused. The electric lamp represents the Sun, the boy's head the Earth, and the orange on a knitting-needle the Moon. As the boy's head gets between the lamp and the orange it throws a shadow on the orange.

A lunar eclipse always happens at the time of full Moon, and we can see why this is so by the picture-diagrams on page 572. For the Earth to cast its shadow upon the Moon, the Moon must be in a line with the Sun and Earth, that is, when we see the whole hemisphere of the Moon which faces us lighted up by the Sun.

As the Moon in its journey round the Earth enters the penumbra of the Earth's shadow no change is noticeable at first. But as it gets near the umbra it becomes slightly darkened. Then when it gets completely into the umbra or dark shadow it is totally eclipsed.

But even then it is not quite invisible, for it has a dark reddish coppery appearance. This is due to the refraction of the Sun's light by the Earth's atmosphere, which acts as a sort of lens. The rays of sunlight enter the atmosphere and are bent and directed upon the Moon's disc. But the Earth's atmosphere absorbs a very large part of the violet rays of the spectrum, and as more of the other end of the spectrum, that is, the red rays, reach the Moon it has a reddish or copper-coloured appearance. It is for the same reason the Sun looks copper-coloured as it is seen through a thick layer of atmosphere just as it drops below the horizon at sunset.

The visibility of the copper-coloured Moon during the actual total eclipse varies a good deal in different eclipses.

This depends upon the state of that part of the Earth's atmosphere which refracts the Sun's light passing to the Moon. During a lunar eclipse in 1884 the Moon was absolutely invisible for a time to the naked eye, a most unusual circumstance on such an occasion.

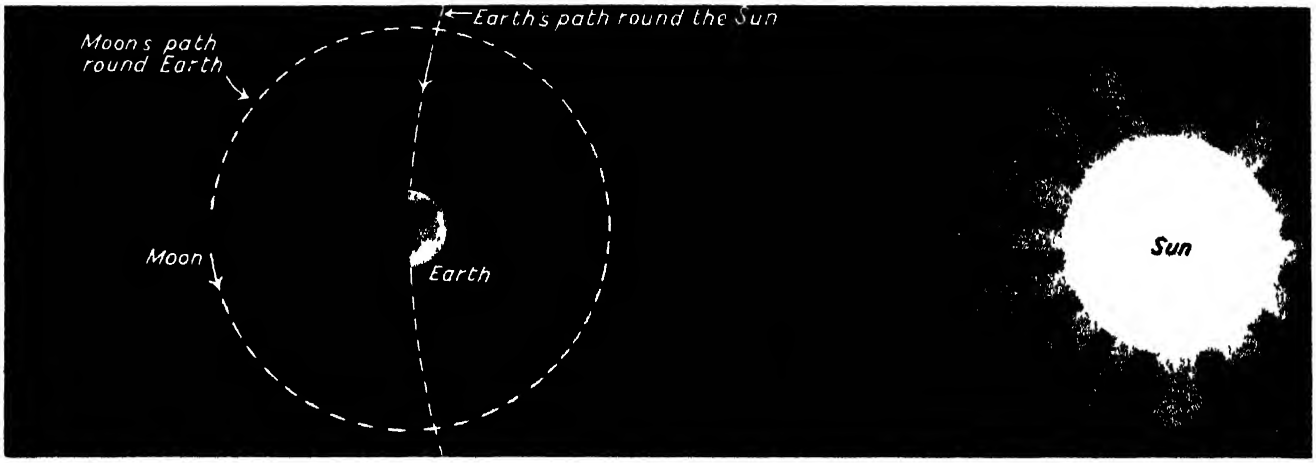
The duration of a total eclipse of the Moon depends upon the Moon's distance from the Earth at the time. Sometimes the Earth's shadow where the Moon crosses it is more than three times the Moon's diameter, while at other times it is little more than twice. Of course, when the width of the shadow is greater the totality of the eclipse lasts longer. When the Moon crosses the centre of the shadow an eclipse may remain total for about two hours, while the whole period from the first contact of the shadow to its final disappearance from the Moon's disc may be altogether four hours.

When the Moon enters the dark part of the Earth's shadow the outline to the naked eye appears sharp and the shadow nearly black by contrast with

the bright parts of the Moon's surface But through a large telescope the outline is so indefinite that it is impossible to say within about half a minute the exact time when the boundary of the shadow has reached any particular point on the Moon's surface

The eclipse tremendously affects the amount of heat which the Moon's surface radiates This heat vanishes almost in the same ratio as the light of heat from the Moon is as great as it was before the eclipse.

As to the number of eclipses that may occur in a year, there may be six, namely, four of the Sun and two of the Moon At very rare intervals, that is, once in a century or two, there may be seven eclipses in a year, four of the Sun and three of the Moon On the other hand, there may be only two eclipses in a year, in both cases of the Sun



In this picture-diagram we see how the Earth, coming between the Sun and the Moon, throws its shadow on the Moon's disc and thus blots out its light. If the Moon passes right through the dark shadow of the Earth, as it is doing here, then the people on half the Earth's surface see a total eclipse. Of course, the Sun is so far away from Earth and Moon that its rays really come in parallel lines In these picture-diagrams, it is important to remember, distances are not drawn to scale

When the Moon passes through only the edge of the shadow cast by the Earth, the whole of its bright disc is not darkened, and we have what is known as a partial eclipse. This picture-diagram shows that in such a case the Sun's light shines on part of the Moon's face, and we then see the eclipse as shown in the bottom left-hand corner

At the moment when the eclipse becomes total at least 98 per cent. of the heat radiated by the Moon has disappeared altogether, and during the period of totality half of the remaining 2 per cent. is lost. But as the shadow passes off and the light returns the heat increases almost as rapidly as it disappeared.

This is a clear proof that the surface of the Moon has very little power of absorbing and storing up heat, a fact which is largely due to the absence of atmosphere. It takes several hours after the eclipse before the radiation

A very interesting fact about an eclipse of the Moon is that when this takes place astronomers are on the look-out to see if the Moon is itself attended by a smaller moon. Such a thing is quite possible, but the Moon's satellite could not be seen owing to the sunlight or moonlight, except at the time of an eclipse. Hitherto the search for this little moon has proved fruitless.

Of course, in the old days an eclipse of the Moon used to cause a great deal of fear among ignorant people, though not so much as an eclipse of the Sun. We are told how on March 1st, 1504, an eclipse of the Moon saved Christopher Columbus and his men from starvation in the West Indies.

The natives were in revolt, and refused to supply the white visitors with provisions Knowing that an eclipse of the Moon was due to take place, Columbus threatened to deprive the natives of the light of the Moon unless they gave him food. They still refused, and he then said he would keep his word. Very soon the eclipse began, and the frightened natives were so awestruck that they threw themselves at the feet of Columbus and agreed to give him all he demanded.

It may not seem wonderful that in these days astronomers can predict the dates of eclipses for centuries to come, but it is certainly remarkable that the people of ancient times could do this. The Chaldeans so far back as 700 B.C., were able to predict fairly accurately when an eclipse of the Sun or Moon would happen, and the Ancient Chinese could do the same.

WONDERS of ANIMAL & PLANT LIFE

THE ROMANTIC STORY OF RUST IN WHEAT

All sorts of pests both animal and vegetable attack the growing crops which man plants for his own use. Insects in different parts of the world take a toll of hundreds of millions of pounds a year from commercial crops of all kinds, and lowly fungus growths exact no less a tribute. In these pages we read the romantic story of one of these fungus pests known as "wheat rust"

Sometimes during a damp summer we may notice that the wheat or oats have brown streaks on the stems and leaves. The streaks are very much the colour of iron rust, and they are also like rust in that they consist of powder which can be easily rubbed off, just as we can rub the powder off a rusty nail.

If we visit the same field later in the season we may often find that these streaks are no longer red but are black, and if we rub them with our hands a black powder comes off, just as the red powder did.

A Pest the Farmer Dreads

What is this curious powder, and what are the streaks that we find on the wheat and sometimes on oats and rye, and even on tall grass? Well, it is a disease that is known to the farmer as rust or mildew, and it is due to a fungus. This rust is a very serious pest, and the farmer dreads it. In one year in the North West part of the United States the yield of wheat was 30,000,000 bushels short owing to damage by rust, and sometimes in some of the American States the whole crop is lost through this fungus.

It is, indeed, one of the most injurious diseases from which cultivated cereals like wheat, oats, barley and rye suffer, and in some countries it is also so abundant on wild grasses that in Sweden it has been found affecting over a hundred different species. Thus, if left unchecked, this rust might seriously affect human life by depriving us of the wheat for our bread.

Yet although rust is such a terrible pest and in some years has cost farmers millions of pounds, its life-story is a most interesting romance.

That the streaks on the wheat were due to a fungus was known hundreds of years ago, but it was only when the microscope came to be used that it was found that the powder on diseased plants consisted of spores, which could spread to other plants and infect them with the disease. Gradually men of science, by infinite patience, have found out the whole story of rust.

A Dangerous Neighbour

The farmers whose crops suffered from rust noticed that the disease appeared only in fields near which the barberry plant happened to be growing. As we probably know, the barberry is a pretty shrub found in woods and hedges, which has yellow flowers hanging in drooping clusters. These change later into oblong orange-red berries, which country people gather and make into a pleasant preserve.

This strange fact about the presence of barberry wherever rust appeared led to investigation, and it was soon seen that where there was no barberry there was no rust on wheat. From this point the life-story of the dreaded fungus disease was gradually traced.

It was found that near the end of the summer yellow or orange patches began to appear on the upper surface of the barberry leaves and even on their flowers and young fruit. This was really the beginning of the plague which affects the wheat and other cereals and at this stage it is known as barberry rust.

If we look at these patches through a powerful microscope we shall notice that they are made up of what appear to be a number of little cups, and on that account this stage of the disease is known as the "cluster cup" stage. But the fungus does not remain on the upper surface of the barberry leaves; it soon eats its way through to the underside and, of course, draws the nourishment it needs from the leaf.

Attacking a Vital Part

The barberry is, indeed, now a sick plant and soon shows the effect of this attack on its vitals. We must remember that it is by means of its leaves that a plant is able to make the starch which it needs, and if the starch making apparatus of the leaf is destroyed or injured the plant cannot thrive. In the case of wheat, it cannot produce useful grain, for the wheat grain is filled with starch.

When the fungus has eaten its way through to the inside of the barberry leaf, little orange coloured globes appear and after a time these open and a number of spores (that is, a kind of seed) drop out. The spores are carried by the wind and if there is a wheat or other cereal crop growing near by they fall on the leaves of the wheat, enter its pores or openings in its substance, and begin to draw nourishment from the wheat leaf. As a result this begins to swell up, the fungus thrives and produces fresh spores, which form the rusty brown streaks on the leaves

In the first picture we see on the left-hand a full, healthy ear of wheat, and on the right an ear of the same kind of wheat which has been attacked by the rust disease. In the second picture we see on the left a leaf of wheat with the powdery spots of red spores looking very much like iron rust, hence the name. On the right we see a stalk of wheat with patches of the later spores, which are black in colour. Both leaf and stalk are shown somewhat magnified

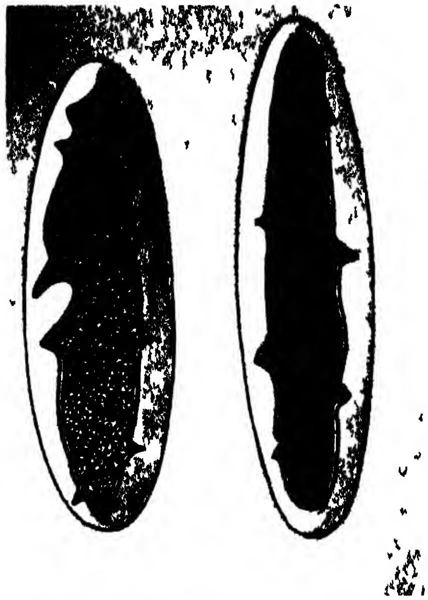
Then the skin of the wheat leaf opens and the spores now known as uredo or blight spores are carried by the wind on to other wheat plants near by, where they in turn develop and produce spores. Thus in a very short time the rust disease spreads through a whole wheatfield and indeed over a whole district.

Getting the Better of Circumstances

But this is not the end of the story, for the rust fungus seems to behave almost as though it had intelligence. When the wheat ripens it is obviously getting near the time when the rust spores will find no shelter. At this stage the fungus begins to produce a different kind of spore which men of science call a teleuto spore, the word meaning completion, and it is these spores that complete the life story of rust for the year.

They fall on the ground and there they remain alive but sleeping right through the winter. Then when the spring comes with its genial sunshine and warmth the teleuto spores germinate in the ground and produce new spores.

Where can these spores find a suitable lodging with plenty of nourishment so that they may live and thrive and produce young to carry on the race? There is no wheat, for the new crop is only just peeping above the ground. The spores therefore, as they are blown by the wind, alight on the barberry leaves and their develop as already explained. Thus we get a complete cycle of life. It is an extraordinary story, this lowly fungus finding a way to live amid all sorts of difficulties.



On the left is shown a spore-case of the red form of rust fungus that attacks the wheat plant, and on the right a spore-case of the black form of rust. In both pictures the spores are greatly magnified

Where the disease is rife it is an important step in abolishing it to root out all the barberry plants, but this alone is not effective, for in some cases the three stages in which the spores develop on barberry, wheat and soil, are not necessary and one stage may be omitted. In lands and climates where a suitable host plant lives throughout the year the uredo stage alone is needed for the continuance of the disease.

Any pest is sooner or later conquered by men of science, and the way in which rust is being conquered is by the production of forms of wheat that are absolutely rust proof. Such a wheat is known as Little Joss and was bred by Professor Biffen of Cambridge University. This wheat can be produced and will flourish in districts where rust is rife, and though the spores may fall upon its leaves they are unable to make any inroads. It is as though an invading army tried to enter a country and was defeated at the very outset.

The Greatest Pest of Crops

The disease of rust was known to the peoples of the ancient Mediterranean countries, and we find references to it in the writings of Aristotle, Strabo, Ovid, Pliny and others. Pliny, indeed, declares that it was the greatest pest of the crops.

The Romans invented a rust god whom they called Robigus, and believed that he could ward off the disease from their crops. On April 25th every year, which was about the time that rust made itself manifest, they celebrated a feast called the Robigalia with the object of pleasing the god Robigus. Sacrifices were offered and the god was implored to spare the crops. No doubt when the disease was less virulent the people believed that Robigus had really helped them as they had implored him to.

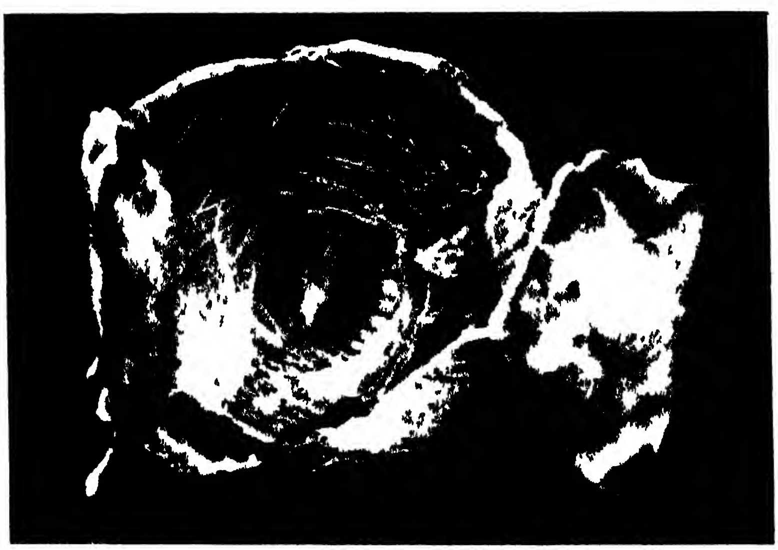
THE QUEER ANTICS OF THE JUMPING BEAN

We may sometimes see men in the streets selling what they describe as jumping beans. These are small nut-like objects which look very dead but which when placed in the warm sunshine for a few moments often begin jumping and moving about. They certainly look very mysterious, and we may well ask what it is that makes the jumping bean jump.

These objects are not really beans at all but parts of the fruit of a large spurge which grows in Mexico. The so-called bean is one of three divisions of the fruit, and it is a small grub inside that sets the bean moving.

When the fruit is on the plant a moth which is a near relation of our codlin moth alights and lays an egg from which in due course a larva is hatched. This larva or caterpillar soon bores its way inside the fruit, eating the material as it goes but leaving the outer skin intact.

By the time the seeds of the spurge plant are ripe the caterpillar inside the bean is fully fed and ready to change into a pupa. It begins to spin a network of silk, and this proves very useful, for when, after the seed has fallen in an exposed place, the hot rays of the sun pour upon it, making the inside of the bean far too warm for its inmate, the little caterpillar can, by striking its head against the wall of its home and using the silk threads as an elastic band, cause the bean to jerk over. The motion is repeated again and again till the insect's home has been taken to a shadier place.



Inside a jumping bean, showing the grub or larva, which causes it to jump. For clearness the "bean" is shown greatly enlarged

It was a long time before the mystery of the jumping bean was solved. At one time the movement was thought to be due to the expansion of the air inside the bean owing to the Sun shining on the outside, but the explanation given has solved the matter.

THE LIFE-STORY OF A FOE THAT PREYS ON WHEAT

Rust is the name given to a fungus pest that preys on the growing wheat and does an immense amount of damage to it The fungus is called rust because it appears as a red powder on the wheat leaves Its life-story pictured here is a great romance It begins on the leaves of the barberry plant, where, seen through the microscope, it appears as little cups that produce spores These blow on to the wheat leaves, enter through the stomata or pores, live on the leaf substance, and later produce spores that spread to other wheat plants Here they germinate and when the wheat ripens produce spores of a different kind, which rest in the ground for the winter and in the spring produce new spores that begin life again on the barberry leaves

AN OPOSSUM LOOKS OUT ON THE WORLD

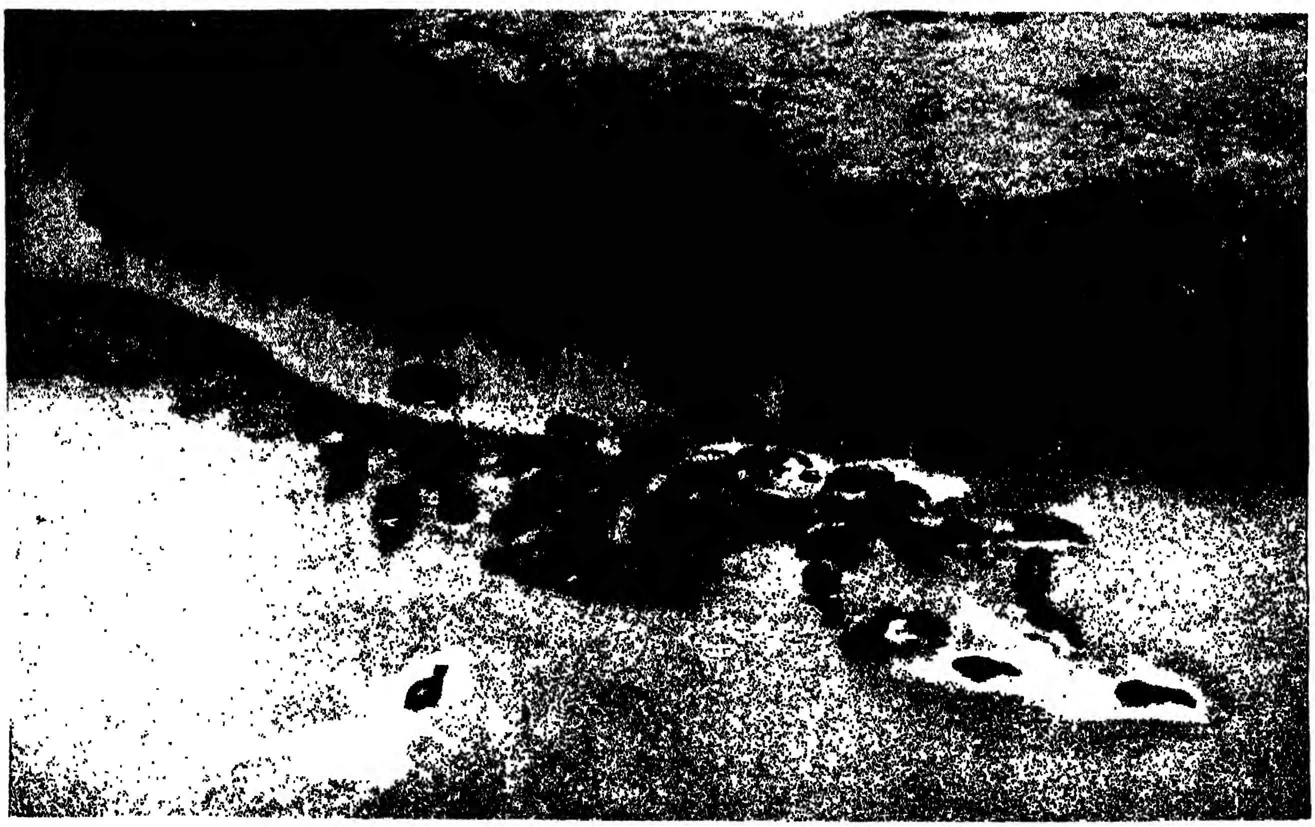
The alert-looking little animal in the photograph is a brush-tailed opossum, a native of Australia, and it has a pocket or pouch like the kangaroo For that reason it is known as a marsupial, a name derived from the Greek word marsupion, which means a little purse or pouch It has grey fur, and is an animal of the night, being rarely seen in the daytime. It lives in the trees and remains so perfectly still for a long period when it suspects enemies, that it is generally mistaken for a part of the tree to which it is clinging The Australian natives are very fond of its flesh It makes an amusing and interesting pet and is fond of bananas Its temper, however, is uncertain. It can give a nasty scratch with its claws, and its bite is unpleasant, though the wound soon heals Tree snakes and dogs are bitter enemies of the opossum, so no wonder it hides in hollow trees except at night, when it hunts for food

THE LIFE-STORY OF THE COLORADO BEETLE

Up to about 1853 the Colorado beetle remained an inhabitant of the Rocky Mountain region, its native home where it fed on common weeds With the increased settlement and cultivation of the United States however, the beetle spread westward and began to prey on the potato plantations, till at last it became a great pest involving the expenditure of hundreds of thousands of pounds a year in the United States and Canada to keep it down Its life-story is told in the pictures on this page Great vigilance has to be exercised to prevent it getting a hold in England and Ireland, where it appears from time to time being imported probably with plants from America The Colorado beetle has many natural enemies including the crow, turkey and various insect parasites Frost, too, kills it off by the million Farmers destroy it by spraying the potato plants with arsenate of lead Plants that are attacked by the Colorado beetle have few potatoes and what there are, are very small indeed Throughout the territory where the beetle is most injurious, and it now covers every area in the United States and Canada where potatoes are grown, there are two generations a year

AFRICAN ANIMALS SEEN FROM THE AIR

Here is a wonderful photograph of a great herd of African elephants in a swamp near the Nile, which is impassable to men and boats. The photograph was taken by Sir Alan Cobham during his flight over Africa. Some years ago African elephants were in great danger of becoming extinct, but owing to protection they have now multiplied greatly and are becoming a nuisance in some areas



This photograph, also taken by Sir Alan Cobham from his aeroplane during his flight across Africa, shows a herd of hippopotami taking to the water. The noise of the engine had evidently alarmed them. They are ponderous animals, but when necessary they can move very quickly, and, although so heavy, swim well in a river. Owing to the advance of civilisation the area in which the hippopotamus lives is becoming more and more restricted. Now it is to be found only round about the rivers Congo, Zambesi and Nile, but in the eighteenth century it is known to have been captured as far north as the Delta of the Nile

THE END OF THE INVINCIBLE ARMADA

The defeat of the Invincible Armada which Philip of Spain sent to conquer England is one of the great decisive events of history. Nothing more dramatic is to be read in the annals of any nation, and never was defeat so crushing. If the Armada had succeeded all history afterwards would have been different and there would probably have been no British Empire. Here is the story of how brave and daring Englishmen, aided by Nature, humbled the pride of the richest and most powerful monarch in the world at that time.

In the latter half of the sixteenth century the mainstay of the Protestant cause in Europe was undoubtedly England. The Reformation had been suppressed in Spain, Italy and in a large part of Germany and the Netherlands, and it was felt by the Pope and the Catholic powers that if only Elizabeth could be turned off the throne and replaced by a Roman Catholic sovereign the whole of Europe would very soon be brought back into the Papal fold. Elizabeth supported the Protestants in the Low Countries against Philip II, the bigot of Spain, and that monarch realised he would never recover his lost provinces until England was subdued.

It is not surprising that Philip should have felt angry with Elizabeth and all her subjects. English privateers were constantly preying on his treasure ships and treasure cities while the nations were nominally at peace, and Elizabeth so far from punishing the freebooters encouraged and honoured them. Not only so, but in English plays the powerful ruler of a large part of Europe and nearly the whole of known America was lampooned and ridiculed in a way that must have infuriated a far lesser man.

It must have been his personal wish as well as a political necessity to chastise the nation and its hostile queen. When in addition the priest-ridden monarch was urged to the conquest of England as a religious duty which would insure the help of the saints and the praise of all heaven, he felt little hesitation, especially as he was convinced that not only was God on his side but the big battalions also.

Philip was absolute monarch over Spain, Portugal and a large part of Italy, and the people of these countries were at that time regarded as the great seafaring nations of the world. It was they who had made the recent wonderful discoveries in the East and the West; it was they who crossed and recrossed the oceans, and it was they who carried on regularly the trading with far distant lands. As a consequence Philip could muster the mightiest navy the world had ever seen, and his warriors were noted throughout Europe as the most skilful and ruthless that were to be found.

Of course, the English had their Drake and Hawkins and other daring privateers who had done great damage to Spanish shipping, but it was felt that success had been due more to the element of surprise and luck than to real superiority. If only the mighty powers of Spain were gathered together and one big concentrated effort made, the upstart island in the north could be subdued, its people chastised, its sovereign dethroned, and the land become practically a vassal of Spain.

Preparations were therefore made in the Spanish, Portuguese and Italian ports to gather together a mighty armada for the conquest of England. It soon came to be called the Invincible Armada. As a fighting force it was to be perfect, and nothing could resist it; but when there was added to this the Pope's blessing and the patronage of the

Drake decides that there is time to finish the game of bowls before beating the Spaniards. From the painting by Seymour Lucas, R.A.

saints victory was placed beyond the shadow of a doubt

In ancient times there was a king of Israel who replied to the boasts of a Syrian monarch a kind of Philip of other days Let not him that girdeth on his harness boast himself as he that putteth it off It is a pity that Philip's many priestly advisers did not give him this good Biblical advice

A Dramatic Moment in History

The coming of the Invincible Armada into English waters and the fate which overtook it have been described as the most dramatic incident in our national history and it is perfectly true It was perhaps the chief turning point in modern history and it is with good reason that Sir Edward Creasy includes it in his Fifteen Decisive Battles of the World

When the Armada was ready Europe stood by in fearful suspense to behold what would be the result of the great cast in the game of human politics If Philip had won the game Protestantism would have died the Inquisition with all its horrors would have been introduced, and the English nation's rise to world power would never have become a fact

After long preparation the great Armada was gathered in the Tagus in the spring of 1588, ready to sail for England Everything had not gone smoothly for the terrible Francis Drake, who had already wrought such havoc in America had entered the Tagus and burned a great deal of the shipping and many of the stores which had been gathered there He with a touch of humour called the exploit "Singeing the King of Spain's beard" and he would probably have destroyed the greater part of the Armada if Elizabeth with the strange perversity which always characterised her, had not forbidden him

It has been said that whom the gods intend to destroy they first make mad and surely Philip was mad when he entrusted the command of his great Armada to the Duke of Medina Sidonia, a wealthy nobleman who knew nothing whatever of navigation disliked the water, suffered from sea sickness and knew none of the commanders who would serve under him

At first it had been intended to give the command to the Marquis of Santa Cruz one of the greatest seamen and naval warriors of his age, but unfortunately for Spain, though luckily for England Santa Cruz who was seventy three years old died before the Armada was ready, otherwise the result of the expedition might not have been what history has recorded

A Master of Delay

Santa Cruz had been all for striking quickly, but Medina Sidonia was a master of procrastination It is one of the mysteries of history why Philip appointed this man to the supreme command in so important an enterprise He did not want the job and did his best to get out of it "My health is bad he wrote to Philip's secretary, "and from my small experience of the water I know that I am always seasick The expedition is on such a scale and the object is of such high importance that the person at the head of it ought to understand navigation and sea fighting, and I know nothing of either. I have not one of those essential qualifications I have no acquaintances among the officers who are to serve under me Santa Cruz had information about the state of things in England I have none Were I competent otherwise, I should have to act in the dark by the opinion of others and I cannot tell to whom I may trust The Adelantado of Castile would do better than I Our Lord would help him for he is a good Christian, and has fought in naval battles If you send me, depend upon it, I shall have a bad account to render of my trust"

Instructions from the King

Medina Sidonia may have been a poor seaman, but he was certainly a good prophet The Duke had his instructions from the King He was to go straight up the English Channel to the North Foreland, and put himself in communication with the Duke of Parma, who was gathering a large army in the Netherlands for the conquest of England

Philip even told him to keep on the English side of the Channel, because the water was deeper there If he fell in with Drake he was to take no notice of him unless he was attacked and was to keep on his course

It is easy to see in reading Philip's instructions, that while he may have anticipated only qualified success, he never dreamt that his Invincible Armada could possibly meet with disaster Were there not 180 priests and friars in the ships, all of whom were praying for success against the heretics? It is true there were only 85 doctors

Drake's ship capturing a Spanish galleon while the English fleet chases the Armada as it sails up the Channel in the form of a half moon From a tapestry destroyed when the old House of Lords was burned in the year 1834

The defeat of the Spanish Armada in the English Channel. From an old painting

and surgeons, but that was regarded as a small matter, for the welfare of men's bodies was as nothing compared with the welfare of their souls.

For Spain it was indeed unfortunate that Santa Cruz had died. While he lived he saw that proper stores were accumulated, but after he had gone rascally contractors began to fleece their country. The Armada was to have sailed in March, but it could not do so, for it was discovered that the salt meat was putrefying in the casks, the water which had stood in barrels for weeks had become poisonous, the supply of powder and ball was short, and there were few spare ropes, spars, or anchors. Froude, the historian, tells us: "The contractors had cheated as audaciously as if they had been mere heretics, and the soldiers and mariners so little liked the look of things that they were deserting in hundreds, while the muster-masters drew pay for the full numbers and kept it"

The Great Armada Starts

It was May 14th before the great Armada of 130 ships with banners flying dropped down the Tagus. It made a fine show. Seven of the ships were over a thousand tons—leviathans for those days—and sixty-seven were over 500 tons. They were armed with 2,430 guns, and the Duke's flagship flew a consecrated banner. The Armada was divided into squadrons under famous commanders, and the men formed a very mixed crowd, for six different languages were spoken on board the ships.

After remaining at anchor at the mouth of the Tagus for a fortnight, the fleet at last set out for sea on May 28th But there was trouble at once. The casks of foul water were leaking, meat and fish were stinking, the biscuits were mouldy, and soon whole crews were suffering from dysentery, while others were poisoned by the bad meat. Not only the men, but the officers also soon lost heart. When the Duke was told by his advisers that he must put into some port for fresh supplies, he was afraid to do so in case his men deserted wholesale.

An Admiral in Distress

By June 10th, when the wind shifted to a suitable quarter and the fleet could sail on its course, practically all the salt meat, fish and cheese were found so putrid that they were thrown overboard for fear of pestilence, and the men had to live on reduced rations of weevily biscuits. The state of things, indeed, was so bad that it was decided the Armada must put into port before it could go on.

Suddenly a gale came on, and many ships were dismasted and otherwise damaged, while large numbers were scattered and lost sight of one another and of shore. The poor Duke was in distress. "It is the more strange," he wrote to Philip, "since we are on the business of the Lord, and some reason there must be for what has befallen us. I told your Majesty that I was unfitted for this command when you asked me to undertake it. I obeyed your orders, and now I am here in Corunna with the ships dispersed and the forces remaining to me inferior to the enemy. The crews are sick and grow daily worse from bad food and water. Most of our provisions have perished and we have not enough for more than two months' consumption"

Eventually the missing ships gathered together and the Armada was revictualled, the fresh food and pure water restoring the sick to health, so that not one died.

Much precious time had been wasted, but on July 22nd the Invincible Armada made its second start from Corunna, and a week later it found itself at the entrance to the English Channel

England's Strength at Sea

Now let us see what preparations had been made in England to meet this great menace Thirty years of peace were supposed to have made the English nation soft and unwarlike, a mistake that the Germans made in 1914 It is not surprising that Philip thought he would easily beat the English, for at this time the English navy consisted of only 38 vessels carrying the Queen's flag, and of these only 13 were over 400 tons.

But to supplement this fleet there were large numbers of privateers fitted out by merchants and others, and armed at their cost, while men like Drake and Hawkins and Lord Howard of Effingham fitted out ships at their own expense. Altogether, during the ten days in which the English and the Spaniards were opposed, the English

fleet consisted of 197 ships, but about half were vessels of less than 100 tons, the size of many sailing yachts to-day. On board there were 15,925 men, whereas the 130 Spanish ships had on board 20,335 men. Protestants and Roman Catholics alike rallied round the Queen, determined to keep out the foreign invader, and Lord Howard of Effingham, the Lord Admiral in charge of the fleet, was a Catholic.

There is no doubt that the Elizabethan period is one of the greatest periods in English history, but it was due to the daring and brilliance of her subjects and not to the ability of the Queen. She is often called "Good Queen Bess," but the way she treated the seamen who were fighting for her throne shows her to have been anything but good.

Like her grandfather, Henry the Seventh, she was mean and ungrateful, and she not only starved her gallant sailors before and during the fight with the Armada, but she did the same after the victory was won. She kept them short of ammunition, so that they could not entirely smash up Philip's great fleet, as they would have done had they been properly equipped, and she let them die of disease and bad food, holding back their wages till many of them had died and no longer required them.

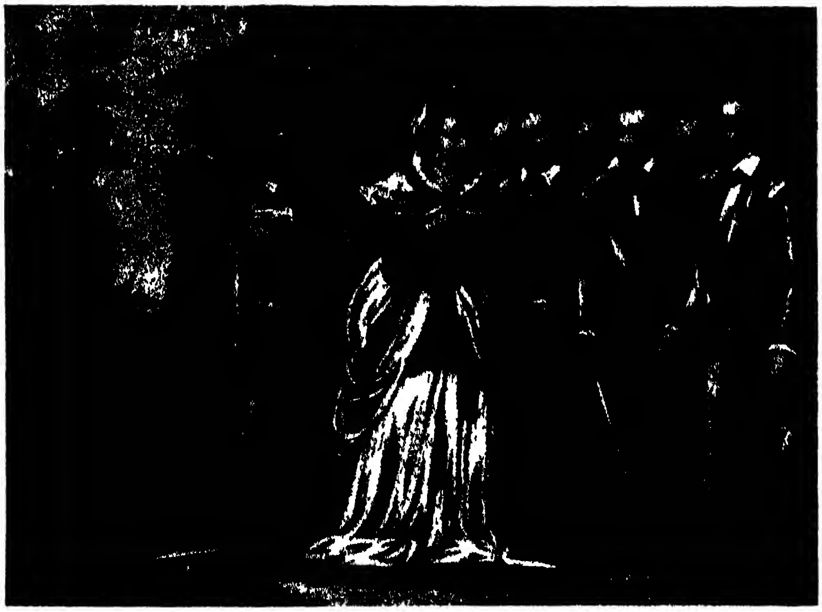
The stores supplied to the British fleet were something like those provided for Philip's men. We are told that one month's provisions were distributed to make them last for six weeks at least, and six men were placed at every four men's mess. The beer provided was sour and poisonous, and caused dysentery, which carried the poor sailors off by scores. Drake and Howard, unable to bear the sight of their men suffering, bought wine and arrowroot at Plymouth on their own responsibility.

A Miserly Sovereign

The miserly Queen afterwards called them to account for what she described as extravagance, an "extravagance" which had probably saved the lives of a thousand gallant men to fight for her. Lord Howard would not defend himself, but paid the bill out of his own purse. Such was the gratitude of "Good Queen Bess."

After the Armada had been sent home, lame and broken, it came to be the fashion to attribute the English victory to a miracle wrought by Providence, but there was no miracle about it. The Spaniards were beaten by better boats, better seamanship, bigger guns, better gunnery, and greater daring.

While the weight of metal which Philip's 2,430 guns could throw exceeded enormously that of the English broadsides, the English guns were larger and had a longer range. Further,



Queen Elizabeth reviewing her troops at Tilbury Fort after the defeat of the Spanish Armada. From the painting by Huck

they fired four shots for every one the Spaniards fired, and their ships sailed two feet for every one the Spaniards could cover. Both sides were badly supplied with ammunition, and several times the English had to break off the action because they had no more powder and shot.

A Famous Game of Bowls

On the afternoon of Friday, July 29th, a pinnace ran into Plymouth Sound with the exciting news that the Spanish Armada was off the Lizard. This was unexpected, for the fleet was supposed to be still refitting in its own harbours. It is said that when the news arrived a game of bowls was being played by the English captains on the Hoe. It is certainly the most famous game in history. Drake, Hawkins, Frobisher, and possibly Lord Howard of Effingham, the English Lord-Admiral, were all taking part in the game, and when the news reached them the captains started to go to their boats, but Drake coolly called them back and insisted that the match should be finished. "There is plenty of time," he said, "to win the game of bowls and beat the Spaniards."

As one historian says, "Drake and his friends aimed their last bowls with the same steady, calculating coolness with which they were about to point their guns. The winning cast was made; and then they went on board and prepared for action with their hearts as light and their nerves as firm as they had been on the Hoe bowling green."

Messengers were sent off at once to London and signals lighted to warn the whole of England that at last the enemy had come. As Lord Macaulay puts it, referring to the beacon fires:

Night sank upon the dusky beach and on the purple sea,
Such night in England ne'er had been, nor e'er again shall be.
From Eddystone to Berwick bounds, from Lynn to Milford Bay,
That time of slumber was as bright and busy as the day;
For swift to east and swift to west the ghastly war-flame spread,
High on St. Michael's Mount it shone; it shone on Beachy Head.
Far on the deep the Spaniard saw, along each southern shire,
Cape beyond cape, in endless range, those twinkling points of fire.

The Spaniards did not take long to find out that they were quite outmatched in seamanship and gunnery by the daring English.

They came up the Channel, and when they approached Plymouth Lord Howard's fleet, which lay between them and the shore, daringly sailed across their front at night and came up in their rear. The Spaniards were astonished, and thought at first that it must be another fleet than that which they had seen the day before, but they were to be surprised still more.

The design of the English vessels had been very much modernised; the high "castles," which fighting ships in those days carried at poop and stem, had been very much reduced in height and size, while the ships themselves had been lengthened to give a greater range of broadside gunfire.

The Spanish Shots Fly Wide

Being faster and lower the Ark, Lord Howard's flagship, and its companions, were able to fly past the Spanish galleons, pouring in a heavy broadside while remaining out of range, and even when they went nearer the Spanish fire passed over their decks and did little harm. Some of the smaller English boats, little bigger than fishing boats of to-day, were quite cheeky. They ran in under the towering galleons of Spain, fired their guns, and ran out again without any harm to themselves.

The Spanish idea of fighting was to close with the enemy as quickly as possible, fix the vessels together with

grappling irons, and then pour over the side, fighting in the same way as in the taking of a castle on land. But the English had no intention of allowing the Spaniards to get near enough for this, and so as the unfortunate Armada sailed up the Channel it was harassed by the English ships following closely on its heels and practising their very effective tactics.

It was not long before the first Spanish vessel was captured, and that was an important one, the flagship of Don Pedro de Valdez, captain of the Andalusian Squadron, with the commander on board. Drake took Don Pedro on board his own ship, while a privateer later towed the Spanish flagship into Torbay. It was a useful capture, for in it were found some tons of gunpowder which were sent by a swift trawler to the English fleet for use against the Spaniards.

Then the flagship of the Spanish Admiral Oquendo blew up, and hundreds of seamen and soldiers were killed. It is said that the captain had struck the master-gunner, who was a German, and he, in a rage, went below and thrust a burning linstock into a powder barrel and then sprang through a porthole into the sea. After the explosion the damaged hull, which was abandoned, was rifled by the English, who again found some unexploded powder barrels in the hold.

The Armada continued up the Channel, the English following and annoying it, and on the night of August 3rd, which was practically without wind, some English boats, seeing two Spanish vessels more or less becalmed behind the main Armada, went out and started towing them away. In the morning, when the wind sprang up, other Spanish ships went to their rescue, and in a collision the rudder of Lord Howard's Ark was lost.

She was now unmanageable, and Spanish ships bore down to capture her; but in a moment a number of her own boats were lowered and, taking her in tow, pulled her round in the right direction, so that she could slip away just as the Spaniards thought they had her within their grasp. We are told that, although the swiftest ships in the whole Armada pursued her, they seemed, in comparison, to be at anchor

Poor Medina Sidonia was quite hurt that the English would not allow him to get alongside and fight in the orthodox way. Writing to the Prince of Parma, he said: "The enemy pursue me. They fire upon me most days from morning to nightfall; but they will not close and grapple. I have given them every opportunity. I have purposely left ships exposed to tempt them to board, but they decline to do it and there is no remedy, for they are swift and we are slow."

The Commander of the Andalusian Squadron of the Spanish Armada surrendering to Sir Francis Drake on board the English admiral's ship The Revenge. From the painting by Seymour Lucas, R.A

The Fate of a Vast Fleet

So things went on till August 6th, when the Duke of Medina Sidonia, afraid his ships might run on the Goodwin Sands, decided to anchor in Calais roads and wait there till Parma was ready. It was a dangerous place, for there were awkward currents. Then came the turning point in the fate of the Armada.

Somewhere about midnight, the watch on the Spanish ships discerned through the gloom certain dark objects drifting on the tide towards the place where their galleons lay thickest Suddenly these mysterious objects burst into flame, and it was then realised that the English were sending down upon the anchored Armada a number of dreaded fire-ships There was nothing original in this idea; fire-ships were a common method of fighting in those days. But the Spaniards were particularly terrified of them, for they had had a dreadful experience with fire-ships at Antwerp not long before, and they thought that these, like those at Antwerp, were loaded with explosives and would scatter destruction all round.

Medina Sidonia gave instructions that all his ships were to cut or slip their cables and make for the open sea. Panic spread through the entire Armada, and though the fire-ships did not reach the Spaniards but burned away harmlessly to the water's edge, they had done their work. They had driven the Armada out of its berth.

One of the galleasses ran aground and was captured, though it had to be given up to the French later, and the bulk of the Spanish ships were mixed up in a tangled, helpless mass, where they became an easy target for the English guns.

Some were sunk, others, badly damaged, drifted helplessly towards Ostend, and as the wind blew hard the hulls of the galleons were heeled over so that they were exposed below their water-line. Shot after shot went through their timbers, killing and wounding hundreds of men and causing nothing but confusion among the huddled masses who had been gathered on board for the conquest of England.

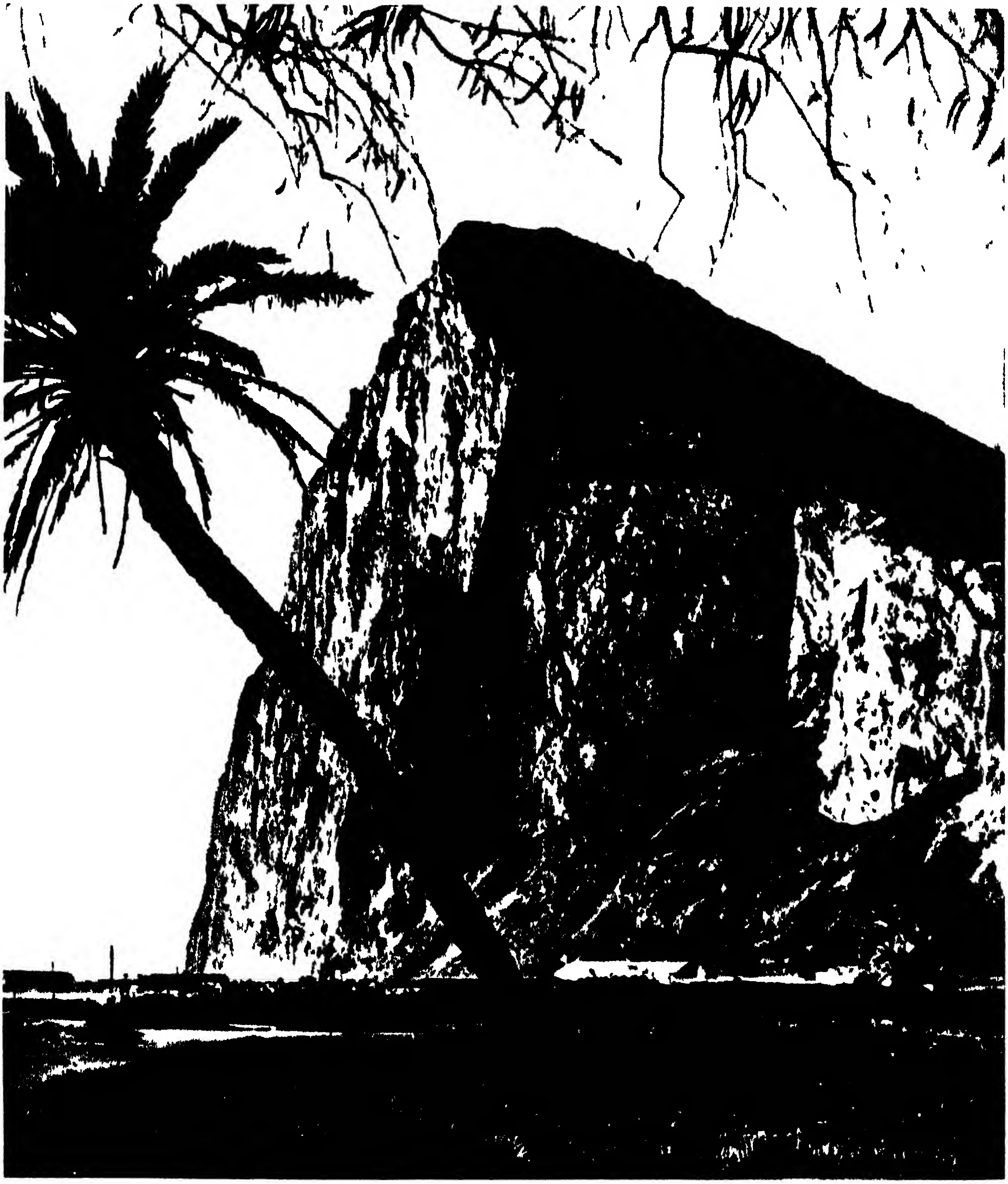
There were gallant captains in the Spanish fleet who wanted to turn and fight the English, but Medina Sidonia had had enough. He was no seaman, and he wanted to get home. So the decision was taken to sail away up the North Sea and round Scotland and Ireland, returning by that long and dangerous route to Spain.

Had the English been properly equipped by their Queen with ammunition and food they could have smashed up the Great Armada so that probably not a single ship would have got back to Spain. But the miserly Queen would not send supplies, and so the Armada escaped the English foes. Howard and Drake chased it as far as the Firth of Forth and then had to turn back, for they had no ammunition for another battle.

But the fate of the Armada was a tragic one. Terrific storms rose, and as the ships passed round the terrible Irish coast one after another was wrecked, and most of the survivors who landed were murdered by the barbarous Irish. Donegal, Mayo, Galway, Clare and Kerry all took their toll, and when many months later the last of the fugitive vessels returned to Spain it was found that no fewer than 64 of those that had sailed so proudly to the conquest of England had been lost with their men The loss of life was more than 10,000.

Among the victors the loss during the ten days of fighting was almost negligible, but many died from sickness.

THE CROUCHING LION THAT GUARDS THE STRAITS



The great rock of Gibraltar, shown here, has been described by Thackeray as "the very image of an enormous lion, crouched between the Atlantic and the Mediterranean, and set there to guard the passage for its British mistress" Its shape certainly is suggestive of a crouching lion and for a couple of centuries or more it has guarded the straits leading into the Mediterranean It used to be true that he who held the rock of Gibraltar controlled that sea But with the coming of modern weapons—the long range gun, the submarine, and the aeroplane much of the value of Gibraltar as a fortress has gone Nevertheless, it is still thought of as a symbol of British might and power Gibraltar consists of a great mass of limestone rock nearly three miles long and half a mile to three-quarters wide. It is nearly four times the height of St Paul's Cathedral In the heart of the rock are a number of caverns which were in ancient times used as dwelling places and as graves In them have been found the remains of prehistoric animals One of the caves, whose entrance is over a thousand feet above the sea, has a hall 230 feet long and 65 feet high Its floor and roof are connected by great stalacite columns fifty feet in height linked by arches at the top Large stalactites and stalagmites are also found in many of the other caves In the 1939-45 war, galleries were tunnelled through the rock to form bomb-proof stores, and an airfield was laid out at its base

WONDERS of LAND & WATER

THE UPS & DOWNS OF GIBRALTAR

Most people would be shocked if they were told that Great Britain was going to lose Gibraltar. For two centuries or more it has stood as a symbol of British impregnability. Nevertheless it is a fact that at some time or other we shall lose this great rock fortress for geologists tell us that it is slowly sinking into the sea. Here we read something about this interesting fact

When we want to suggest that a thing is firm and unchangeable we often speak of it as impregnable as the Rock of Gibraltar. But is the Rock of Gibraltar impregnable? Is it so firm that it can never be moved?

Well, geologists tell us that so far from this being the case Gibraltar is slowly sinking into the sea and that one day it is likely to disappear altogether. Of course, it will not be in our time, for the movement is very slow but it is none the less sure.

Like other parts of the world such for example, as the English Downs Gibraltar was once under the sea. The Rock is made up of limestone, and as we know limestone consists of the remains of little creatures that lived in the sea long ages ago.

But apart from its formation we know that Gibraltar has been under the sea, for at various points on its surface there are beaches which at some time or other must have been at or below the sea level.

Gibraltar is now 1 306 feet above the sea level, but we know from these beaches that at some time it was not more than 700 feet high, and was then an island unconnected with Spain. Embedded in the hardened sands of these beaches we find the shells of creatures which lived in the sea.

But how do the geologists know that Gibraltar is again sinking into the sea? Well there are several reasons. In the first place, Gibraltar rests upon a great rocky ledge or shelf that at one time reached out into the sea for nearly half a mile from the present shore line, and ended in a cliff. There is little doubt that at one time this submerged ledge was the top of a cliff that looked out on to the Mediterranean.

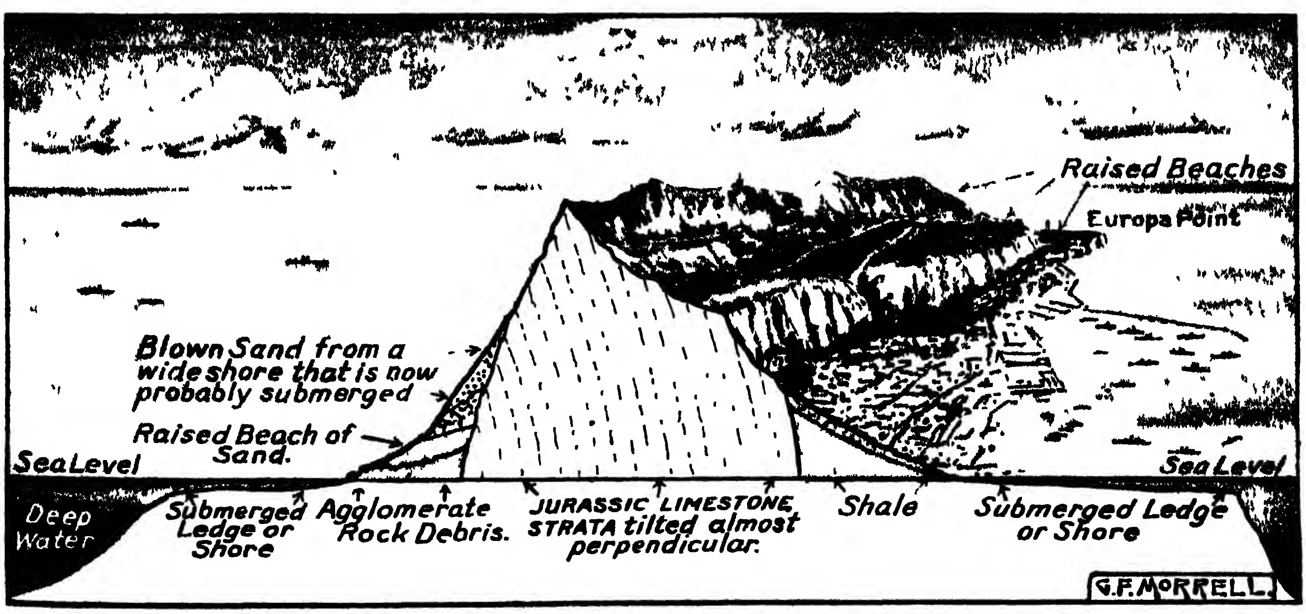
Then high up on the east side of the Rock near Catalan Bay is a large area of sand which has been blown there. But where did it come from? There is no known existing source from which the sand can have blown and Professor Geikie has declared that it must have drifted from a sandy beach that once existed to the east of the Rock. This beach was, no doubt, the submerged ledge, as shown in the picture diagram on this page.

Then in the third place beneath the surface of the Isthmus of Linea which links the Rock with Spain, there is a layer of sand, about 30 feet deep, containing shells of a kind that are found in the Mediterranean to-day. Then comes a layer of clay about two feet thick, and below that more sand to a great depth.

Now the clay represents material that has been washed down in comparatively recent times from the higher lands of Spain. It must have been above ground when this was done but the land has since sunk.

Of course, the subsidence of the great Rock is very slow indeed. If we can judge by the rate at which other parts of Europe's western seaboard are sinking then it would not be more than about a foot in a century, so that 130 000 years would elapse before Gibraltar was finally lost to us. Of course many things may happen before that time. Other geological factors may come in, and instead of the submergence being continued there might be another elevation.

But in addition to the general subsidence of that part of the Earth's crust there is, of course, the regular weathering of the Rock, which in the course of ages would wear it level. Rain, wind, heat and cold all have their part in disintegrating the limestone. The Rock looks very firm and solid as we pass it in a ship, and it is therefore all the more startling to hear that at some time we must lose it.



This picture-diagram by Mr. G. F. Morrell, the well-known geologist, shows a vertical section through the Rock of Gibraltar. The rock is situated on a submerged ledge, the edge of which represents a shore-line that once extended from a quarter to half a mile out to sea from the present shore-line, and this, with various other indications, seems to show that though the rock has risen out of the sea it is now gradually sinking back again and will one day disappear from sight

THE REGIONS OF FROST AND FIRE

LOFTY MOUNTAINS WHERE SNOW & HEAT EXIST TOGETHER

One of the strangest contradictions in the whole of the world of Nature is the fact that frost and fire, snow and molten rock should be closely linked together. Yet such we find in the case of many of the three hundred volcanoes or more that are scattered about the Earth's crust and form safety valves for the molten material beneath the solid exterior.

The peaks of some of these volcanoes found in northern latitudes and along the lofty range of the Andes are perpetually snow-clad. Yet from time to time they belch out fire and molten rock.

We might well ask how it is that a mountain which is a vent for white-hot rock and has fire beneath it can be cold enough for snow to rest upon its slopes.

Well, it is true that the lava streams out at a white heat either over the edge of the crater or, as more often happens, through fissures in the sides of the cone. It is very hot when it first comes out and flows rapidly, but soon it begins to cool and it is not long before a solid crust forms over the molten stream, which moves more and more slowly as it travels farther from the vent of origin.

The Lava Crust

The crust of a lava stream is a poor conductor of heat, and because of that the outside may be quite cool while underneath and not very far down, the rock is still molten.

This fact that the solidified lava is a bad conductor of heat acts in two ways. In the first place it makes the outside of the crust cool and it further has the effect of preventing the heat of the molten rock below from escaping through the crust into the air.

This naturally results in the molten rock retaining its heat much longer than it would otherwise do, and so it continues to flow and often bursts through the cool crust that is rapidly forming in the front of the lava stream.

That lava when cool is a bad conductor of heat results in the slopes of an active crater being often quite cold, and when snow falls it remains frozen in its strange position. Yet the fire may not be very far off, and anyone who climbs to the top of the crater and looks over may see the molten rock below.

The World's Highest Volcano

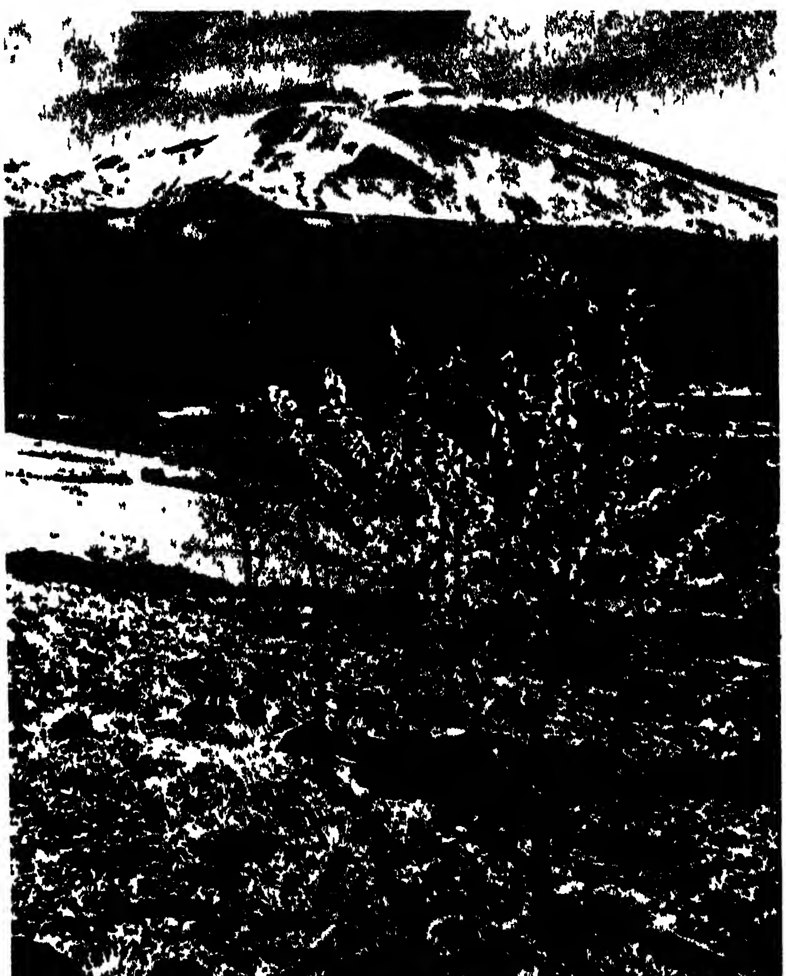
Cotopaxi, which rises in the Andes of Ecuador to a height of 19,613 feet, or nearly four miles above the level of the sea, is the highest active volcano in the world, and it is perpetually snow-covered. Yet over the crater, which is half a mile in diameter, a fiery glow is visible at night. In eruption vast quantities of hot ashes are thrown out through the mouth of this volcano, and the heat of these, by melting the snow on the slopes of the cone, causes very destructive floods which sweep into the valleys below.

It is not, however, only the loftiest volcanoes that have snow on their slopes. Even Etna, which is less than 11,000 feet high, is under snow during a large part of the year.

Formerly, of course, the Earth was much more subject to volcanic action than it is now. It is not often that we get a huge eruption, but in past ages there must have been eruptions compared with which the most severe we have experienced during the last few hundred years are mere child's play.

In the states of Idaho, Washington, and Oregon there is an area of 200,000 square miles known as the Columbia Plateau, which is formed of a series of lava sheets. In some places the lava is nearly a mile thick, and we can have only a faint idea of the eruption that could pour out such vast masses of molten rock.

Volcanoes have done a great deal of harm from man's point of view by destroying life, human, animal and plant. Large areas of once fertile country have been devastated and turned into rocky wildernesses. Yet the work of volcanoes has not been altogether without use. The burial of organic remains by streams of lava has preserved many fossils that throw light on the past history of life on the globe. Even such a destructive eruption as that of Vesuvius which buried the cities of Pompeii and Herculaneum preserved a record of Roman life without which we should have known much less than we do about it.



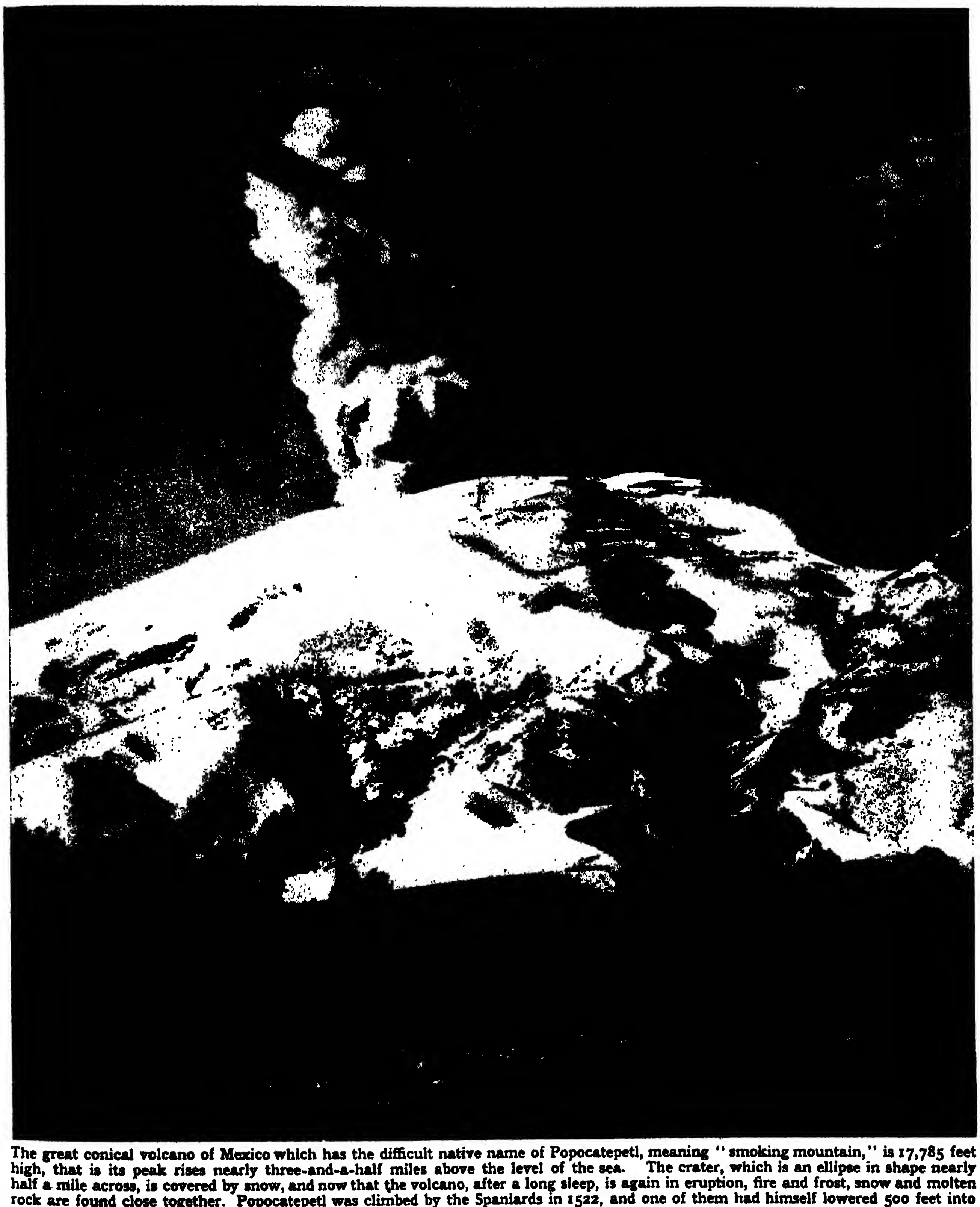
Mount Etna, the Sicilian volcano, with snow on its cone not far removed from the fire and molten rock of its interior

Volcanic Soil

The lava and ash poured out by volcanoes, after being weathered, make one of the richest soils in the world. The dust and ashes, when consolidated, form a soft stone known as tuff, which hardens in the air and provides an excellent building material. Some of the oldest sewers in Rome, which were built of tuff 2,500 years ago, are still in excellent condition.

Some time ago a Scottish firm purchased the cone of Vulcano, a small Mediterranean volcano, in order to get from it alum, boracic acid and sulphur, all of which are products of these fiery mountains.

A SNOW-CLAD VOLCANO OVER 3 MILES HIGH



The great conical volcano of Mexico which has the difficult native name of Popocatepetl, meaning "smoking mountain," is 17,785 feet high, that is its peak rises nearly three-and-a-half miles above the level of the sea. The crater, which is an ellipse in shape nearly half a mile across, is covered by snow, and now that the volcano, after a long sleep, is again in eruption, fire and frost, snow and molten rock are found close together. Popocatepetl was climbed by the Spaniards in 1522, and one of them had himself lowered 500 feet into the crater, but it was not climbed again till 1827. Since then it has been scaled many times. The soldiers of Cortes, during the Conquest of Mexico by the Spaniards, obtained sulphur from the crater for the making of gunpowder, and in the centuries that have followed more than a hundred million tons of sulphur are said to have been taken from the mountain. Even when the volcano is sleeping fumes of sulphur come out of the fissures in the crater and are seen to rise from the mountain top. The crater itself is bell-shaped, and one side is much lower than the other. It is here that the sulphur is drawn up by a windlass from the inside of the crater, whose floor covers an area of nearly half a square mile. The walls of the crater are multi-coloured, owing to the reflection of light from the blue sky above, and the smoking sulphur is strangely mingled with the snow that lies in every crack and crevice. Popocatepetl is a striking example of the close proximity of heat and cold

THE SANDS ENCROACH ON CIVILISATION

In the regions surrounding the Sahara and the great Desert of Gobi in Asia the sands are ever encroaching upon the haunts of civilisation. They are relentless in their movement and nothing can stop them. In this picture we see how the sands are burying an oasis in the Sahara. The wind-driven sand changes its position, but some always remains, and eventually this oasis will be obliterated

This picture shows another part of the Sahara, with its moving hills of sand. Thousands of years ago this region was fertile, but the invading sands buried the water supplies and covered the soil, so that nothing now remains but a great waste of sand stretching for miles in all directions. The same thing is found in Asia, where under the sands of the Desert of Gobi the remains have been found of a flourishing civilisation. In less than half a century a great lake known as Lob Nor has almost entirely disappeared under the sand

THE WONDER OF AN ALARM CLOCK

Alarm clocks are very clever pieces of mechanism, and yet their operation is quite simple and can be understood by all. They are by no means a recent invention, but have been in existence for hundreds of years, and here we read about them and learn how it is that the alarm goes off at the hour for which it is set

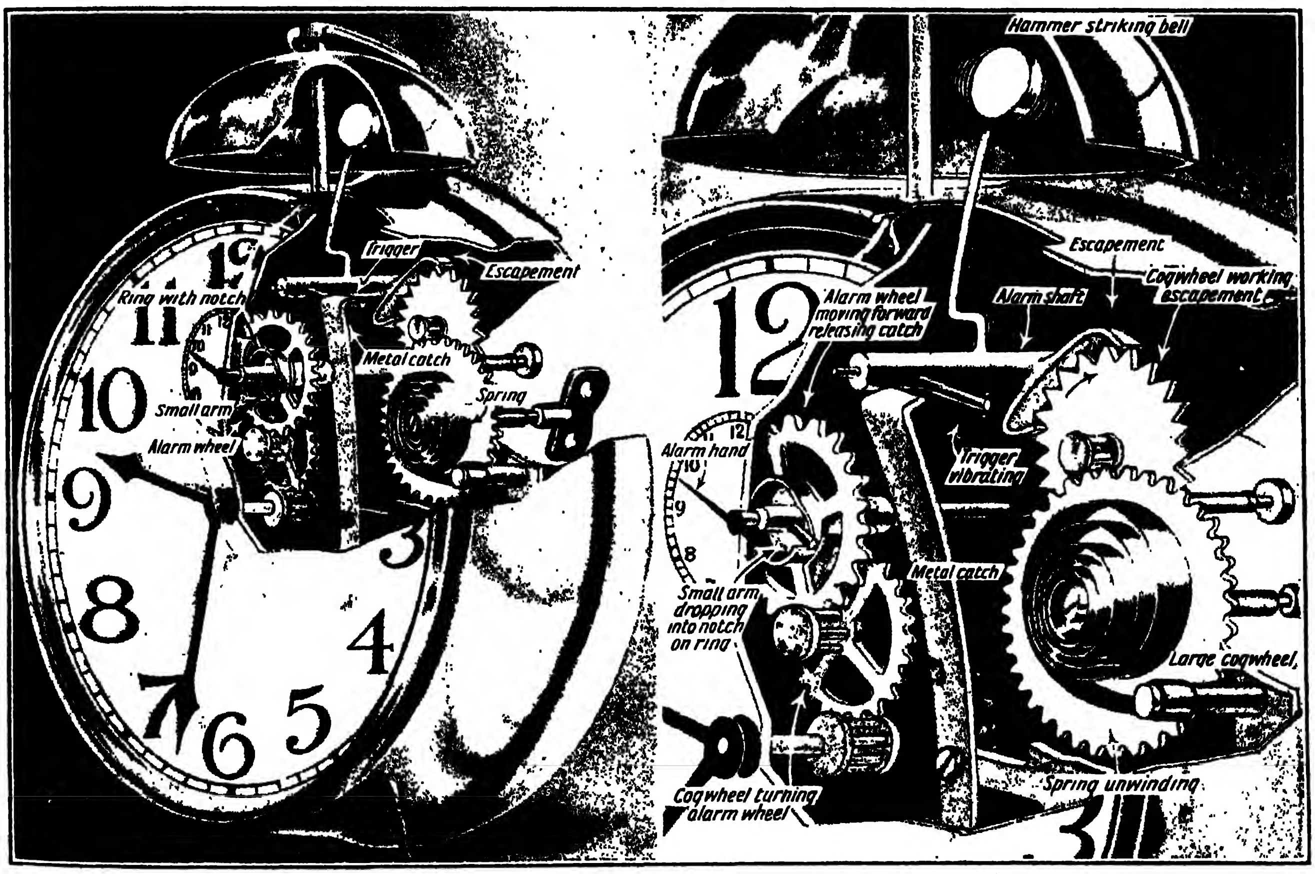
It will probably be a surprise to many readers to learn that the alarm clock is by no means a recent invention. There were alarm clocks, and even alarm watches, so far back as the middle of the sixteenth century. There is, for example, a very handsome striking and alarm clock in existence which once belonged to the son of King Henry the Fourth of France, and there are some very beautiful alarm watches of the same period. So far from these being great rarities, there were many such alarm timepieces and they worked excellently.

The Editor of this book saw an alarm watch of a rather later period which still worked, and rang at the exact time it was set, and it had been doing so for over two hundred years.

It is one of the most interesting and astonishing facts of mechanical history that the first really intricate and accurate machines which showed real ingenuity and skill in workmanship were watches and clocks. Indeed, there are many ancient timepieces which are still telling the time accurately and have been working without interruption for hundreds of years.

Of course, there have been improvements of various kinds, and chronometers will now record the exact time almost with mathematical accuracy. But the clock is still in principle the same machine that it was almost in its earliest day. Of no other type of machine made so far back as the sixteenth century can it be said that there have been so few real developments.

The old clock and watchmakers were masters of ingenuity and technical skill. The advance that has come in clock and watch-making has been along the lines of mass production and the cheapening of the product. Anybody can now get a reasonably accurate timekeeper, a clock, a watch, or even an alarm clock, for a few shillings. In the old days, of course, clocks cost pounds, and were out of reach of all but the rich. Such choice articles descended from father to son.

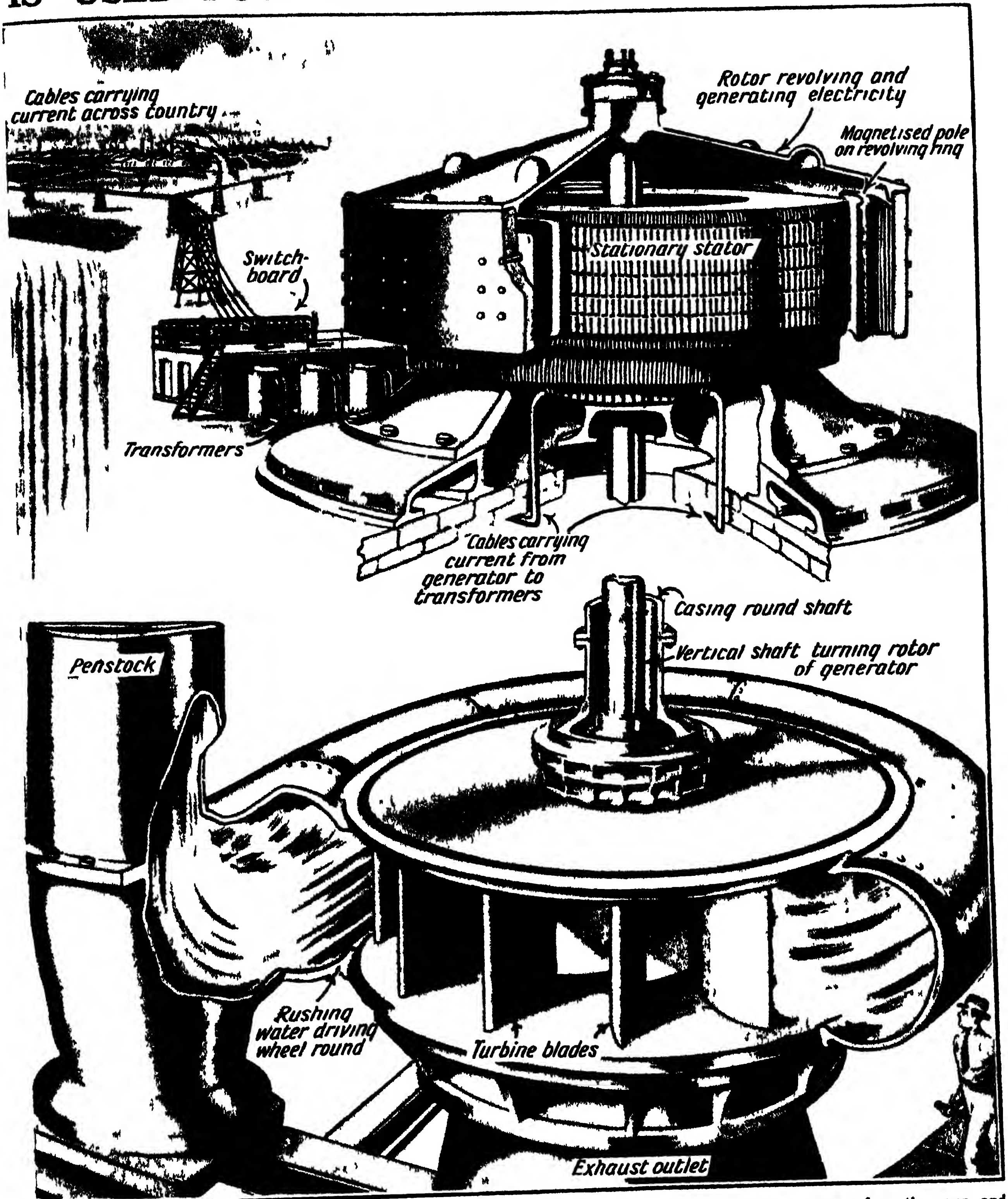


These pictures show how an alarm clock goes off at the right time. A cogwheel which showly turns an alarm wheel is in connection with the clock's hour hand. When the alarm is not ringing a long metal catch holds back a trigger. The release of the trigger to set the alarm ringing at the right moment is brought about in this way. The metal catch is held in check by the enlarged spindle of the alarm wheel, as shown in the left-hand picture, and on that spindle is a small arm jutting out parallel with the alarm hand. This small arm is resting on the edge of a ring with a notch in it. The alarm hand and the small arm remain stationary, but the metal ring moves round slowly with the hour hand. When the notch in the ring comes opposite the small arm, the ring with the alarm wheel and its spindle fly forward with a click, and this releases the pressure on the metal catch which at once moves, releasing the trigger and freeing the escapement. At once the cogwheel in contact with the escapement begins moving round, being turned by a large cogwheel connected with the alarm spring that has previously been wound up. While this spring is unwinding the cogwheels move, and as the escapement goes to and fro the hammer fastened to its shaft strikes the bell

HOW THE POWER OF NIAGARA FALLS

Water-power is more and more being used for the production of electricity to light cities and keep the machinery of factories going. The outstanding example of this is Niagara Falls, and in this picture, which runs across two pages, we are shown in graphic form how the water of the Niagara River is harnessed so that it will turn huge turbines or water-wheels and work generators for producing the electricity. The water of the river above the falls is diverted into a canal, at the end of which it passes into penstocks, or huge vertical pipes. It falls to the bottom of these with terrific force, and is then diverted horizontally so that it rushes against the blades of great turbines. One of these is shown on the right of the picture. As the wheel rotates it turns a vertical shaft, which revolves a rotor to which it is connected, as seen in the top right-hand corner, and as this goes round it generates the electricity in the same way as a generator turned by steam-power. The electricity thus produced is conveyed by cables to transformers and then passes through a switchboard and, by means of overhead cables, is carried across country to factories and cities. This is the principle adopted wherever

IS USED FOR PRODUCING ELECTRICITY



water-power is used for generating electricity At Niagara there are several hydro-electric plants drawing power from the river, and altogether their capacity is nearly a million horse-power One of these plants is the largest single hydro-electric development in the world, and the cost of the power-house, which contains nine generators, with the turbines and other parts, was £16,000,000 The fall of water here is 305 feet and the canal by which it is drawn from the Niagara River is 48 feet wide and is lined with concrete The continued development of the Niagara power stations has led to fears that if more and more water is drawn from the river there will one day be no Falls left An agreement has therefore been come to by which the water that may be taken from Niagara River for power purposes is limited to 36,000 cubic feet per second on the Canadian side, and on the United States side to 20,000 cubic feet per second The electricity which is generated at Niagara is used over a wide area for driving trains and tramcars and machinery in factories and for giving light and heat. Some of it is transmitted for a distance of over two hundred miles from the Falls

INSIDE THE OLD AND NEW GASHOLDERS

Here we see the insides of two gasholders, incorrectly called gasometers In the foreground is the new type, which consists of an outer casing of wood or steel, with a metal cylinder inside Gas enters through a control valve and raises a pressed steel piston which slides on rollers There are moulded rubber rings all round which form an air-tight joint When the piston is down, the top part of the gasholder is empty except for air, and it is lighted by windows As more and more gas enters, the piston rises On the right is the older form of gasholder In this, gas enters through a pipe raised above the level of water in a tank The holder is made in sections, which fit over one another telescope fashion These float in the water until gas enters, when they rise, and the gas is prevented from escaping by means of gas-tight "cup and dip" joints The water in the tank prevents the gas from escaping below As the gas enters, the smallest telescopic section rises first, then the second and finally the third At the bottom we see the cup and dip joint drawn on a large scale

STRANGE FACTS ABOUT ELASTICITY

What is the most elastic substance you know? Probably you will say at once, "India-rubber." But this is far from being the case. There are many other solid substances which are much more elastic than rubber, and yet you would hardly think them elastic at all — such substances, for example, as glass and ivory and steel. In fact, if you have never thought about the matter, you will find in these pages many facts that will surprise you.

We all know what is meant when an article or material is described as "elastic." Elastic is defined in the dictionary as "having the power of returning to the form from which a body is bent, extended, pressed or distorted," and this is a very good description.

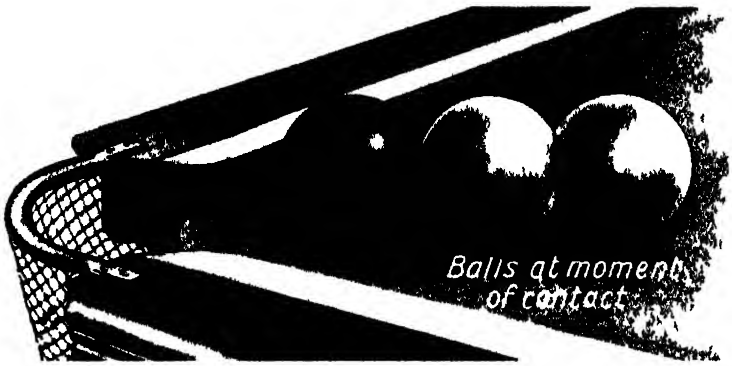
For example, we recognise that india-rubber is elastic. It is indeed the outstanding symbol of elasticity in the popular mind. If we take a piece of india-rubber and bend it double it springs back to its former shape and size. If we take an india-rubber band and stretch it out to three times its original length and then let go, it springs back to its normal size in a moment.

Similarly, if we press heavily with our hand on a rubber pad it is compressed, but directly we remove our hand it returns to its former shape; and if we take the rubber pad and twist it round and round, when we let go it again returns to its previous form.

But we are quite wrong in supposing that india-rubber is the most elastic of all substances. Perhaps it will come as a surprise to know that ivory and glass are much more elastic, and steel is still more so. Indeed, steel is one of the most elastic of all substances.

On page 595 we find a number of experiments which we can carry out to show the relative elasticity of various bodies, and we see there that a steel ball if dropped on the ground will bounce up to a much greater height than a rubber ball.

But if it is true that many other solid substances are far more elastic than india-rubber, it is equally true that there are plenty of solid substances which have so little elasticity that they may almost be said to be without this property.



When billiard balls strike one another they are compressed out of shape a great deal, and if our eyes could only see quickly enough the balls would look like this. Being elastic they at once spring back into the spherical shape.

Many people will be surprised to hear that the ivory billiard balls which seem so hard and unyielding are really much more elastic than rubber balls. The reason they spring apart so rapidly after striking one another is because of their elasticity. When they come in contact their surfaces are pressed more or less flat as shown in the upper picture.

Think of dough, for example, and test a piece next time a piecrust is being made. It is very ductile, that is, it can be drawn out into a thin strip, but when you have once drawn it out it remains like that and does not spring back like the elastic band.

Clay is another example of an inelastic body, and it would be interesting to sit down and make a list of bodies which show practically no elasticity. Butter, lard and greases of all kinds are outstanding examples.

Plastic Bodies

Bodies and materials that are inelastic are generally spoken of as being "plastic," a word that comes from the Greek word for "mould." A plastic body like clay or dough or butter can be moulded to any shape.

"Elastic" also comes from a Greek word meaning "beaten out." It is not so suitable a word for the property which we describe as elasticity as is the word "plastic" is for the property which it represents.

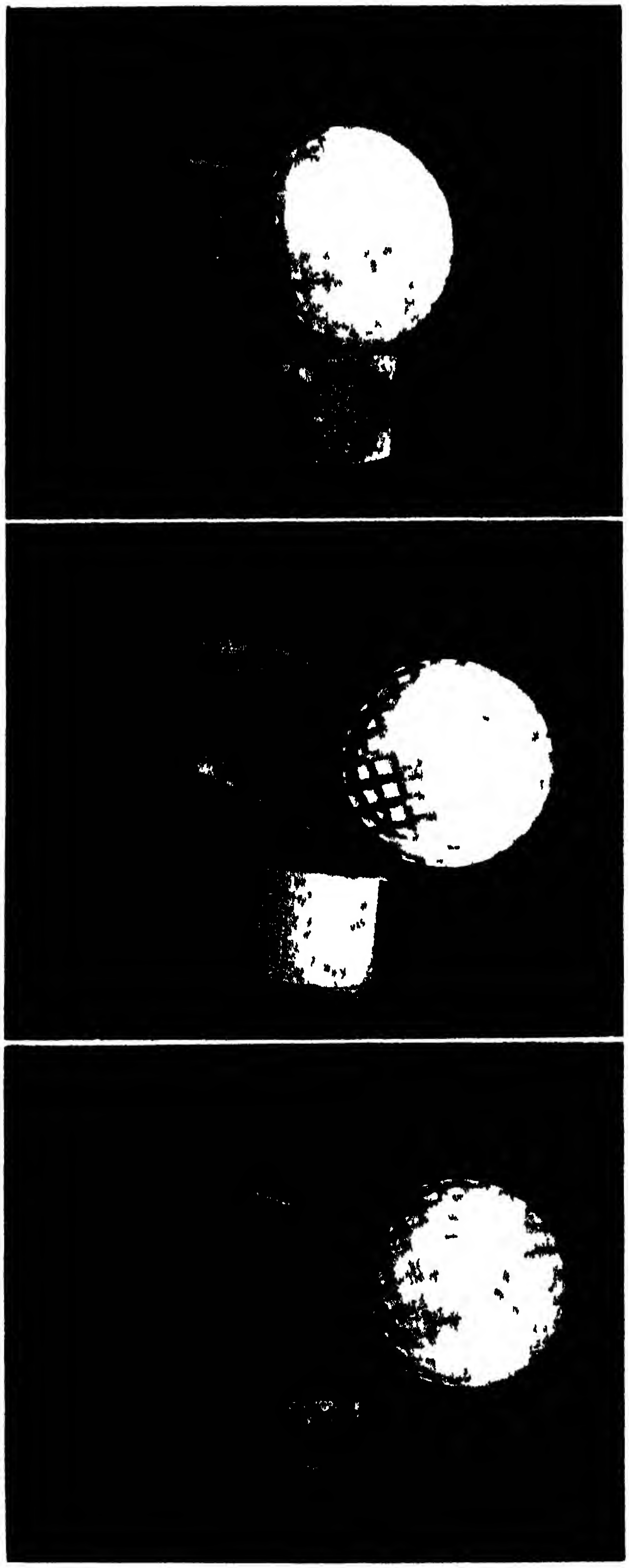
Of course elastic materials vary a great deal in the degree to which they can be distorted or extended and then spring back to their former size and shape. A cane, for example, is very elastic and can be bent round a good deal, returning to its original form. A lath of wood is also elastic, but it cannot be bent round so far as the cane. If we bend it a little it will return to its former shape, but if we go on bending it there will be an ominous crack and we shall find that we have broken the lath. A man of science would say that we had reached the limit of elasticity in the lath.

Limits of Elasticity

For all elastic substances there is a limit of elasticity, that is, a degree beyond which we cannot bend or distort them further without altering their permanent shape. We know this is true with a cane, for if we give it a sharp bend, nearly doubling it over, it will not return to the straight form that it had.

On the other hand, the well-tempered steel blades of swords can be bent right round and yet spring back to their original form. That is one of the tests of a really fine sword blade.

Similarly, if a substance is stretched or strained beyond its limits of elasticity it becomes more or less plastic. If a vehicle on springs is constantly overloaded, the springs will lose their elasticity and become permanently set, that is, they will no longer be as springy as they were. In the same way, if a pile of heavy books is kept in an arm chair and more and more books are piled on and left for weeks in this position, the springs of the chair will lose their elasticity and become set like those of the vehicle.



A marvellous series of photographs showing the elasticity of a golf ball. These photographs were taken at the Massachusetts Institute of Technology, by whose courtesy they are published here. The exposure was one 50,000th of a second, and we can see, in the top picture, how the side of the ball is flattened as the golf club strikes it, how the ball has sprung back horizontally to an elongated shape, in the second picture, and how, in the third picture, the elasticity has caused a bulge on the right side.

Hooke's Law

The degree of elasticity of a material can be measured by suspending it and gradually adding weights to the end. There comes at last a point when the material will not return wholly to its original size or length.

A famous English scientist, Robert Hooke, who died in 1703, made many experiments in connection with this property of elasticity, and he formulated a law which is called by his name, Hooke's Law. This law declares that the amount of distortion of an elastic body is directly proportional to the force producing it.

When we bend or twist or press a substance we are said to strain it, and elasticity is the resistance to this strain which the body exercises. There are two kinds of strain, one resulting in a change of form, as when we bend a cane or twist a rubber band, and the other resulting in a change of volume, as when we squeeze a piece of rubber into smaller compass.

It is because of the great elasticity of steel, more than that of any other metal, that it is used so extensively in the construction of bridges.

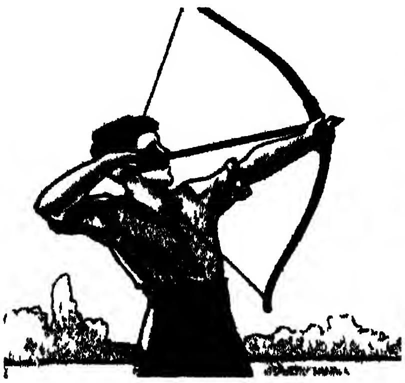
Marvellous Photographs

The remarkable photographs on this page showing the elasticity of a golf ball were taken at the Massachusetts Institute of Technology by means of a special electric circuit designed by Dr. Harold Edgerton and Mr. Kenneth J. Germeshausen to produce a flashlight of great intensity. Between the first and the last photographs the club had travelled a distance of less than half an inch. In the top photograph the great elasticity of the ball is shown by the remarkable flattening and in the last the bulge on the right side shows that the elastic ball is still oscillating from the impact of the club.

EXPERIMENTS THAT ILLUSTRATE ELASTICITY

There are very many interesting experiments which we can carry out to illustrate the property of elasticity

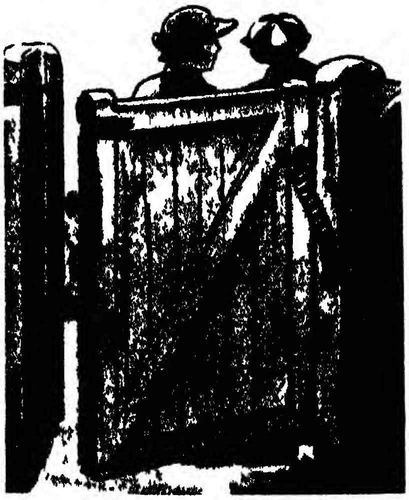
Substances are not all equally elastic as we can test for ourselves if we take a strip of india-rubber a cane a lath of wood a piece of whalebone a rod of steel a rod of brass a strip of zinc and a strip of lead



A bow, when stretched, returns to its former shape

If we try to bend these various substances and then release them to see how quickly and how readily they return to their former shape we shall find that substances like rubber and whalebone and steel are much more elastic than substances like wood and zinc and lead In fact lead has very little elasticity at all

Take a bow and arrow and go out into a field and fire the arrow You draw your bow and the cane or yew of which it is made can be stretched greatly Then when you let the string go and the arrow



A spring is stretched when a gate is opened, but being elastic it returns to its former shape directly the pressure on it is released, and so closes the gate

flies the cane or yew of the bow returns to its normal position because it is so very elastic

Similarly if we take a cane and swish it it will go up and down so rapidly that we can scarcely see it Yet the moment we stop swishing it will return to its former straight position But if we take it and bend it smartly right round with a jerk we shall find that it will remain bent for there are limits of elasticity even to a cane

Wood is elastic though not so elastic as cane The next time we go to the

A diving-board is elastic, for when the diver bends it down with his weight it springs back to its former position directly it is released

open air swimming bath let us watch the spring board as a diver leaps off into the water He sways the end of the board up and down for a few moments before jumping to give him a good spring and the reason this can be done is that the wood is elastic He presses it down but its elasticity causes it to return to its former horizontal position

A steel ball, shown on the right, and a glass marble, on the left, are both elastic and are flattened at the moment they strike a stone surface This is proved by the marks they leave if the surface is greased

Many metals are elastic but steel is the most elastic of all It is this fact that makes it such a useful metal and it is the elasticity of steel that makes a spring so useful in a watch or on a gate Next time you go through a gate or door that has a spiral spring on it watch the spring You will see that the steel spring is stretched when the gate is opened and because it is elastic it returns to its former shape and size and pulls the gate back

To prove that steel is much more elastic than rubber and that a substance like clay is not elastic at all we should take a small ball of clay a small rubber ball and a steel ball such as a ball bearing Drop these all from the same height on to a

A cane swings to and fro because it is elastic

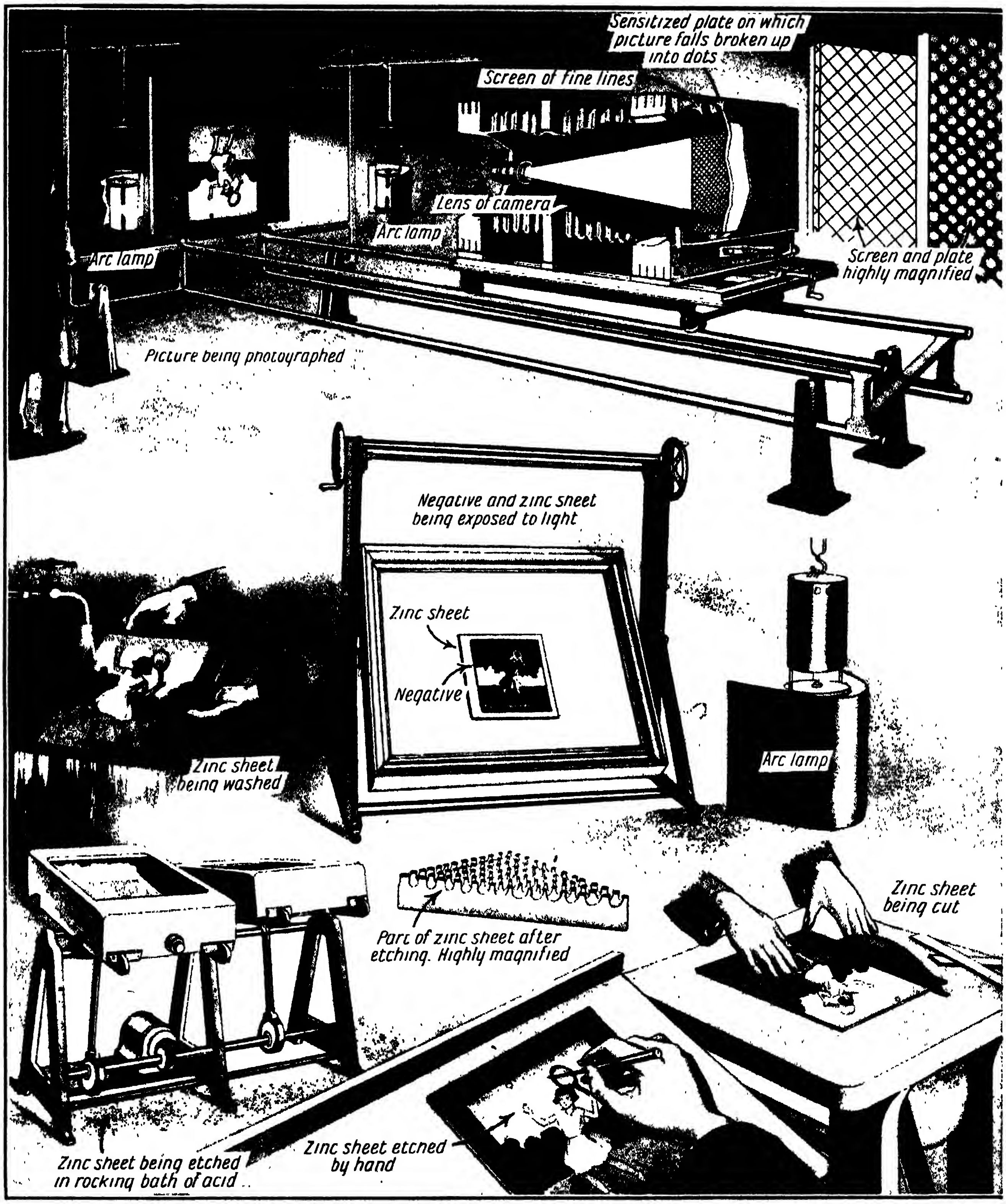
paving stone The clay ball will not bounce at all the rubber ball will bounce a fair height but the steel ball will go much higher than the rubber ball

We may carry out still another experiment Smear a smooth stone surface with grease Now drop upon it two balls say a glass marble and a steel ball bearing Catch them as they bounce up and examine the grease mark on the ball and the mark left on the stone These marks will be of considerable diameter Now lay the balls gently on the stone and pick

If balls of clay, rubber and steel are dropped from the same height, the steel bounces highest because it is the most elastic The clay does not bounce at all

them up without letting them roll You will see that only a point of grease remains where they came in contact with the stone The larger marks when they were dropped is a proof that the substance was flattened The mark made by the bouncing steel ball is bigger than that made by the glass because steel is more elastic

HOW IT IS POSSIBLE TO REPRODUCE



In these pages we see how drawings and photographs can be reproduced in newspapers and magazines. First of all, as in the top left-hand corner, the photograph to be reproduced is placed upright in front of a huge camera. Arc lamps on either side illuminate the picture, and its image falls on a sensitised plate at the back of the camera. But between the plate and the lens of the camera is placed a screen of very fine lines, crossing one another diagonally. The light from the photograph has to pass through this screen and so the image is cast on the plate in the form of a series of dots. In other words, the lines of the screen divide the picture up into myriads of tiny points. The dots appear close together in the dark parts of the picture. If you look at any picture in this book through a magnifying glass you will see that it is made up of dots. The paper being glazed, a fine screen can be used with many small dots close together. In a newspaper picture it will be seen that a coarser screen has to be used and the dots are larger, resulting in the loss of much detail. After exposure the plate is developed and fixed like an ordinary photographic negative, and dried in a heated cabinet. Next a sheet of zinc coated with fish glue is taken, and the glass negative is put in contact with the glue in a printing-frame. This

PICTURES IN PAPERS & MAGAZINES

is covered with rubber, and has the air withdrawn from it by a pump. The vacuum inside the frame insures even contact between negative and zinc plate. The frame is now turned over and the plate exposed for about 15 minutes to the glare of arc lamps, the light passing through the negative and falling on the glue surface. Wherever the light falls the glue hardens, but through the dark part of the negative no light can pass, and the glue remains soft. The plate is now placed under a tap and most of the soft glue washed away, the harder parts remaining. The plate is next placed in an etching bath of acid, rocked by means of a motor and cams. As the acid swishes over the plate it eats away the soft zinc in the parts which have no glue covering. The result is a zinc plate whose surface is a mass of little points, because the dark lines formed by the screen received no light in the printing-frame, and the glue on these parts remained soft and was removed by the water and acid. The plate is now further etched by hand, the light parts being accentuated. It is then cut to size and mounted on wood or lead, and when it is inked a proof can be taken on paper which is an exact reproduction of the original picture. The block is then set up with the type to make a page, and printing takes place in the ordinary way

THE MYSTERY OF THE SIPHON EXPLAINED

We have probably seen at some time or other outside an hotel men drawing liquid from a large cask in a van or lorry and filling a copper vessel with it by means of a curious bent tube that has one arm longer than the other.

This tube is called a siphon, and the word is simply a Greek word for a tube. We may have wondered why it is that the liquid first runs up the short arm of the tube and then down the long one, for it seems against the laws of nature for a liquid to run uphill as this is done.

Well, the explanation is quite simple. Before the siphon can be made to work the tube must first be filled with the liquid, or after the short arm has been placed in the vessel from which the liquid is to be drawn the air must be drawn out of the long arm by means of the mouth or in some other way.

The Two Arms

Here is what happens. The siphon is filled with liquid and the two ends being closed in some way, the short arm is dipped into the liquid in the vessel to be emptied. The end of the short arm is generally made to reach down almost to the bottom of the vessel. When the end of the long arm is opened the liquid will at once begin to run out and it will continue to run so long as the end of the short arm is in the liquid of the upper vessel.

The science of the siphon is this. The column of liquid is supported in the short arm by the pressure of the air on the surface of the fluid in the upper vessel. This pressure, as we know, is 14·7 pounds on every square inch of surface.

The bent tube is a kind of balance, but there is naturally a greater weight of liquid in the long arm than in the short for the simple reason that there is more liquid in it.

Pressing upward on the opening of the short arm is a pressure equal to that of the atmosphere less the pressure caused by the weight of the liquid in that arm which is pressing down. Similarly, pressing upward on the opening of the long arm is the pressure of the atmosphere less the pressure caused by the weight of the liquid in the long arm. But the weight of liquid in the long arm is much more than the weight of liquid in the short arm, and so instead of balancing the fluid runs down and out of the long arm.

As it does so a vacuum would be caused in the upper part of the tube near the bend were it not for the fact that the liquid from the short tube follows on to fill the place where the vacuum would occur. The pressure of the atmosphere on the fluid in the upper vessel keeps pushing it up the short arm and the flow is continued so long as the short arm is immersed in the liquid.

It can thus be seen that the siphon is a very useful device for drawing water from an upper vessel into a lower one, or for emptying a tank or cistern, as shown in the picture. It is made great use of in industry, and even nature uses the siphon, as in the intermittent springs about which we read in another part of this book.

There is an amusing toy known as a Tantalus Cup. Tantalus was the thirsty son of Jupiter, who was doomed to stand up to his chin in water, and whenever he tried to drink found that the water receded. In the Tantalus Cup an image of the god in a vessel has a siphon concealed inside him. Water is poured into the vessel, and as soon as it approaches the figure's mouth it is drawn off by the siphon and flows away through the bottom of the vessel.

The use of the siphon was known to the ancient Egyptians, for we find representations of it on their tombs, dating so far back as 1450 B.C. In one of these pictures a man is exhausting the air from a siphon with his mouth, preparatory to placing the lower end of the long arm in a vessel and drawing off liquid from an upper vessel. Other siphons are shown already at work.

Here is a siphon at work. The weight of liquid in the long arm causes it to run out, and pressure of air on the liquid in the tank above drives water up the short arm to fill what would be a vacuum near the bend. The flow continues till the liquid in the tank is below the opening of the short arm

Huge Siphons

Siphons of large size are used in emptying dykes and drains. In such cases the large bent tube is made of iron and is of great diameter. To start the siphon working the ends are stopped with plugs and the pipe is filled with water through a funnel, the air inside escaping through a cock. When filled with water the pipe has its cock closed.

The term "siphon" is sometimes used for a bent pipe used the other way up for taking water from one hill to another across an intervening valley. In this case, however, the term is incorrect, for the water passes from one hill to the other through the bent pipe by finding its own level.

It is interesting to remember that a siphon for water cannot work if it is higher than 33 feet above the water surface, because the pressure of the air will not support a column of water in the pipe higher than that.

WONDERS OF THE SKY

STRANGE MESSENGERS FROM SPACE

Comets have always inspired fear in ignorant peoples, and perhaps it is not surprising, for their visits are few and far between, and they are queer-looking objects, with their tails which change their position as the comets travel in their orbits. Most comets have three parts, a head which looks something like a nebula, a nucleus, or star-like point near the middle of the head, and a luminous tail which may stretch away for millions of miles. In these pages is given much interesting information about comets

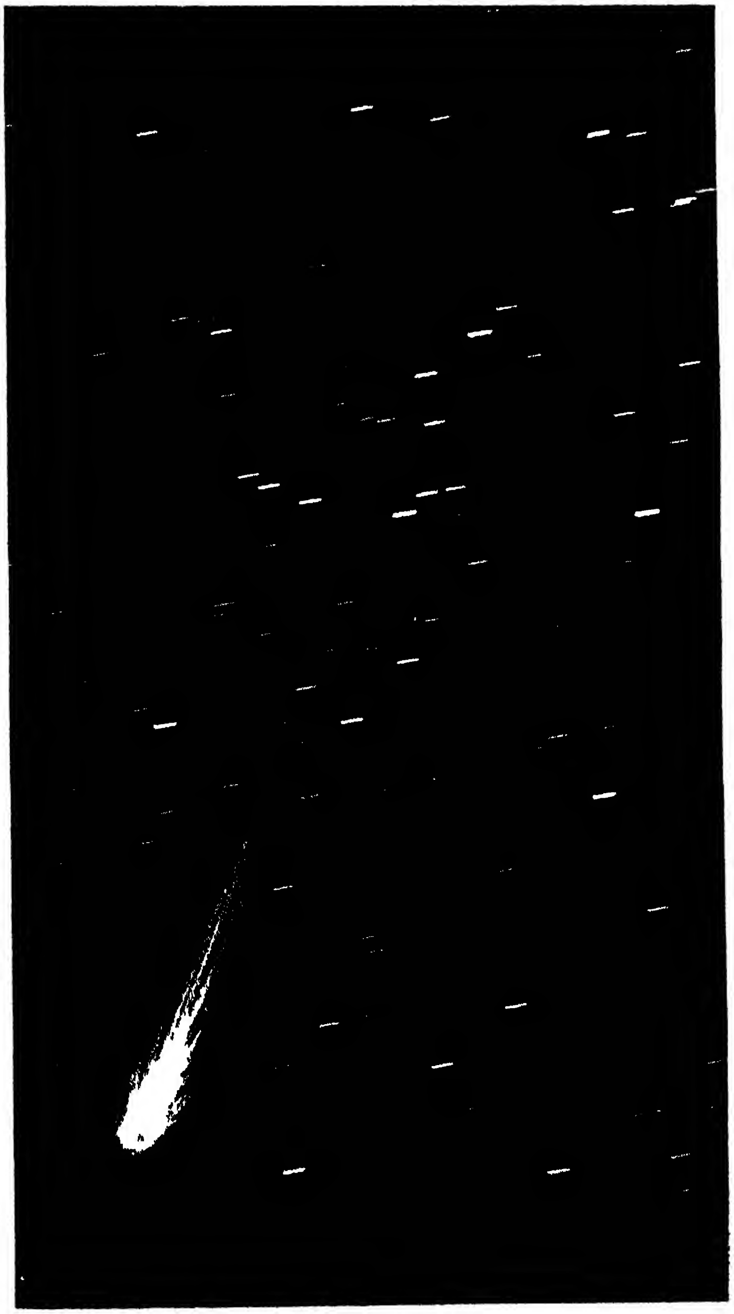
Of all the objects that appear in the heavens and are visible to the naked eye, the queerest and most mysterious are the comets. It is not often that we can see a comet, and indeed, there has been no really fine comet visible to the naked eye in England since 1882.

Owing to their rare appearance and their strange form, it is not surprising that in the past, when men knew little about the real nature of the heavenly bodies, comets caused great fear, and their appearance was supposed to betoken some great catastrophe. Shakespeare refers to this in his play "Julius Caesar," when he makes Calphurnia, Caesar's wife, say, "When beggars die there are no comets seen; the heavens themselves blaze forth the death of princes."

Comets in History

A comet is said to have been seen shortly after the murder of Caesar, and Josephus records that another comet appeared in the year 66, just before the fall of Jerusalem. An old chronicler of the seventeenth century sums up the matter in a rhyme:

Whene'er a comet doth appear
Comes mishap, want, sorrow and fear;
And never hath a comet's sheen
Without great evil yet been seen.
These dire ill fortunes do ensue
When a comet appears to view—
Fever, sickness, plague and death,
Hard times, need and hunger's scathe,
Great heat, drought and barren Nature,
War, murder, riots, fire and slaughter,
Frost, cold, storm and wind and water,
For high folk death, or humble lot,
Ill winds and earthquakes in many a spot;
Such mishaps everywhere arise
When comets course across the skies.



A photograph of Morehouse's Comet, taken at Greenwich Observatory on October 27th, 1908. It was named after Daniel Walter Morehouse, of Yerkes Observatory, U.S.A., who discovered it in that year. The stars appear as short white lines, owing to the length of the exposure

We must not laugh at these old people who feared such appearances in the sky and consider ourselves superior to them. We must remember that we ourselves should be alarmed at some very mysterious and strange appearance that could not be explained. Of course, we know now the nature of the comets, although astronomers have still some facts to find out about them.

Comets That Disappear

What are comets? Well, they are strange visitors from space moving in curved paths which bring them from time to time near our Sun. Some of these comets appear again and again, at intervals, while others are seen once and then go off into space and are never seen again. Some continue to exist year after year while others are divided into two or more parts or are broken up altogether and only come to our notice as periodical showers of meteors. We read about these meteoric showers in another part of this book.

All the big comets and many similar ones consist of three parts. First of all there is the head or coma, consisting of a hazy cloud of luminous transparent matter. "Coma" is a Latin word and comes from the Greek word 'kome,' meaning "the hair of the head." The name "comet" was

given to these celestial visitors because the comet looked something like a head of hair

Then in the second place near the centre of the comet is a bright point or sometimes two or three points known as the nucleus. This only appears when the comet in its journey comes near the Sun and in some of the smaller comets it is not seen at all

Finally there is the tail or train a stream of light sometimes many millions of miles long. It follows the comet as the comet approaches the Sun and then as the comet ... the Sun the tail is turned away and finally when the comet moves away once more into space the tail ... the ... to call the tail of the comet at this point ... sometimes the tail ... and sometimes ... Then ... the Sun ... the tail ... with which the comet ... travelling

What Comets Are Made Of

Now what is a comet made of? It ... composed of small solid fragments each carrying with it ... light is produced ... by electric discharge ... Astronomers ... the particles some think they may be large rocks but others refer to a comet's head as a ... bank and others ... of it as a dust cloud and even a smoke wreath. Probably it is made up of grains like ... many feet apart

The tail is believed to be formed of a great mass of very tiny particles which have been first of all thrown out from the nucleus towards the Sun and afterward repelled by both the nucleus and the Sun. It is thought to be the pressure of the Sun's radiation that drives off the comet's very much drawn out tail

While the particles individually may be solid matter the density of the tail as a whole and indeed of the complete comet is very very light because the particles are so widely separated from one another. The mean density of many comets which have been ... has been estimated at only one ... part of that of the Earth ... that ... cubic ... of comet would weigh only ... much as ... of air. When we produce the nearest thing to a vacuum that is possible by using the very best kind of air pump, the density of what is left in the vacuum is about the same as that of the comet

We know a comet's matter is drawn out to an almost inconceivable extent, because in the first place small stars are often seen through the head of a comet even near its nucleus, with scarcely any reduction of their light, and when comets pass near a planet, such as Jupiter they have no effect at all upon its orbit as they would do unless their mass were extremely small

On one occasion in 1886 a comet actually passed between Jupiter and the orbit of its first satellite. Not one of the satellites of the planet was affected in any way although the comet's orbit was changed. On other occasions comets have come so near to the Earth that their orbits have been changed but the Earth was not affected in any way. If the comets had had a mass as great as only one 100 000th of that of the Earth the length of our year would have been altered by one second but as it was not changed at all, it is obvious that the comet's mass must have been extremely small

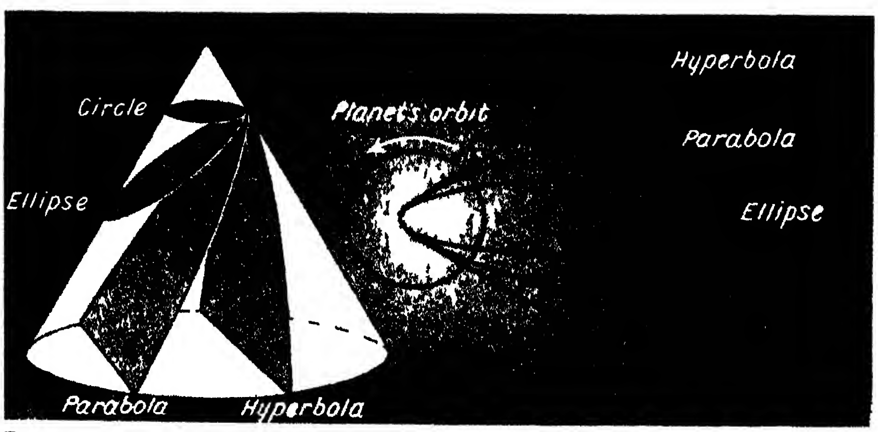
Halley's Comet, photographed at Lowell Observatory, U S A, on May 13th, 1910. Of all comets this is the most famous, for before its appearance in 1682 these strange objects were supposed to be merely chance visitors. Halley declared that the comet of 1682 was a member of the solar system and would again become visible in 1758 which prediction was fulfilled

The Size and Mass of Comets

One astronomer tells us that 100 000 of the largest comets ever seen would not weigh so much as our Earth. One of the smaller of the minor planets probably outweighs the largest of the comets in weight and it is not without reason that an astronomer has described the comets as "airy nothings"

Yet although their mass is so remarkably small their bulk is extremely large. In fact comets are the largest bodies known in the heavens except the Nebulae. In many cases they fill a space thousands of times larger than our Sun or the great stars

The head or coma is sometimes 150 000 miles in diameter and even larger ones have been known. A comet less than 10 000 miles in diameter would probably not be discovered at all even with a telescope. The head of a great comet seen in 1811 at one time measured 1 200 000 miles and a comet seen in 1892 had a head with a diameter of 700 000 miles. The diameter of the head varies and curiously enough as it approaches the Sun it contracts but when it recedes once more it begins to expand. The reason for this is not known but Sir John Herschel suggested that when near the Sun some nebulous matter in the head evaporates as a result of the solar heat and becomes invisible while as



The orbits of planets are ellipses, which are almost circular, but those of comets are very much drawn out and this picture shows the different forms of comet orbits. They are all in the shape of sections of a cone as indicated by the figure on the left

the comet travels away from the Sun to cooler regions this matter condenses and appears once again. The question is, however, a mystery which has not yet been solved.

The nucleus of the comet is much smaller. Sometimes it appears as a mere point and cannot be more than 100 miles in diameter, while at other times it exceeds [illegible] miles. It also changes in size from day to day.

But the greatest bulk of the comet is found in its tail. This is rarely less than five million miles long, and sometimes exceeds 100 million miles. The giant comet of 1843 had a tail 155 million miles long.

By examining the light of the comet with the aid of the spectroscope we find that most of its light is reflected sunlight, but lines which appear on the spectrum show that it also shines with a certain amount of light of its own. This is believed to be due not to heat but, as already stated, to electric discharges from the particles caused by the Sun's action on them as the comet rushes towards the Sun.

Really large comets are very splendid objects in the sky, and sometimes appear as bright as Venus. Occasionally the head and nucleus are so large and dazzling that they can be seen even in daylight. One such was the giant comet of 1910, which was easily visible in bright daylight.

Comets are often named after their discoverers, and the most famous of all comets is known as Halley's comet. Before the time of that great astronomer comets were thought to be merely chance visitors which arrived mysteriously within view of the Earth and then disappeared just as mysteriously as they had come and would never be seen again.

But Halley, when a great comet appeared in 1682, connected it with comets which had appeared in 1607 and 1531, and declared that it was probably the same comet and would appear again in 1758. He maintained that it was revolving round the Sun and that it took about 75 years to complete its orbit. Sure enough, it appeared again in 1758, and it has appeared since, its last visit being in 1910, when a distinguished astronomer wrote the following rather amusing verse:

> Of all the objects in the sky
> There's none like Comet Halley;
> We see it with the naked eye
> And periodically.
> The first to see it wasn't he,
> But still we call it Halley;
> The notion that it would return
> Was his originally.

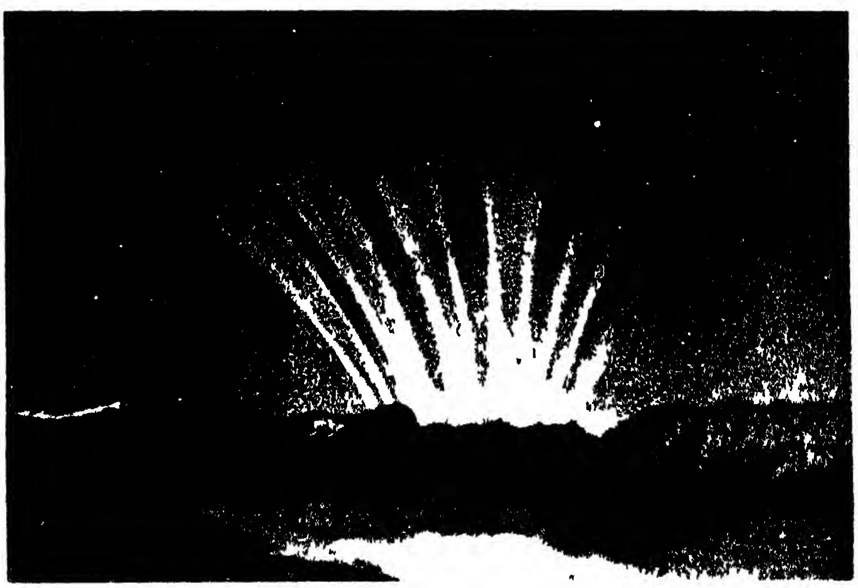
The great comet of 1843, as seen from Paris. It was a grand and wonderful sight, the tail extending across one third of the heavens, and the nucleus appearing as big as Venus

Comets often behave very curiously. Biela's Comet, seen in 1826, returned according to prediction in 1845, and in the following January divided into two parts. In 1852, when it was again observed, the two parts were travelling side by side, but were now separated by a distance of a million and a quarter miles. In 1872, when it was due back near the Sun, no comet appeared, but there was a magnificent display of meteors, and it was found that the orbit of the meteors corresponded with the orbit of the vanished comet. It is probable, therefore, that the shooting stars were the remains of Biela's comet.

The orbits of these comets which appear again and again are much more elongated than those of the planets, and they vary enormously in size. Halley's Comet approaches within a few million miles of the Sun and then travels away more than 3,000 million miles, far beyond the orbit of Neptune. On the other hand, there are comets which approach to within 100,000 miles of the Sun.

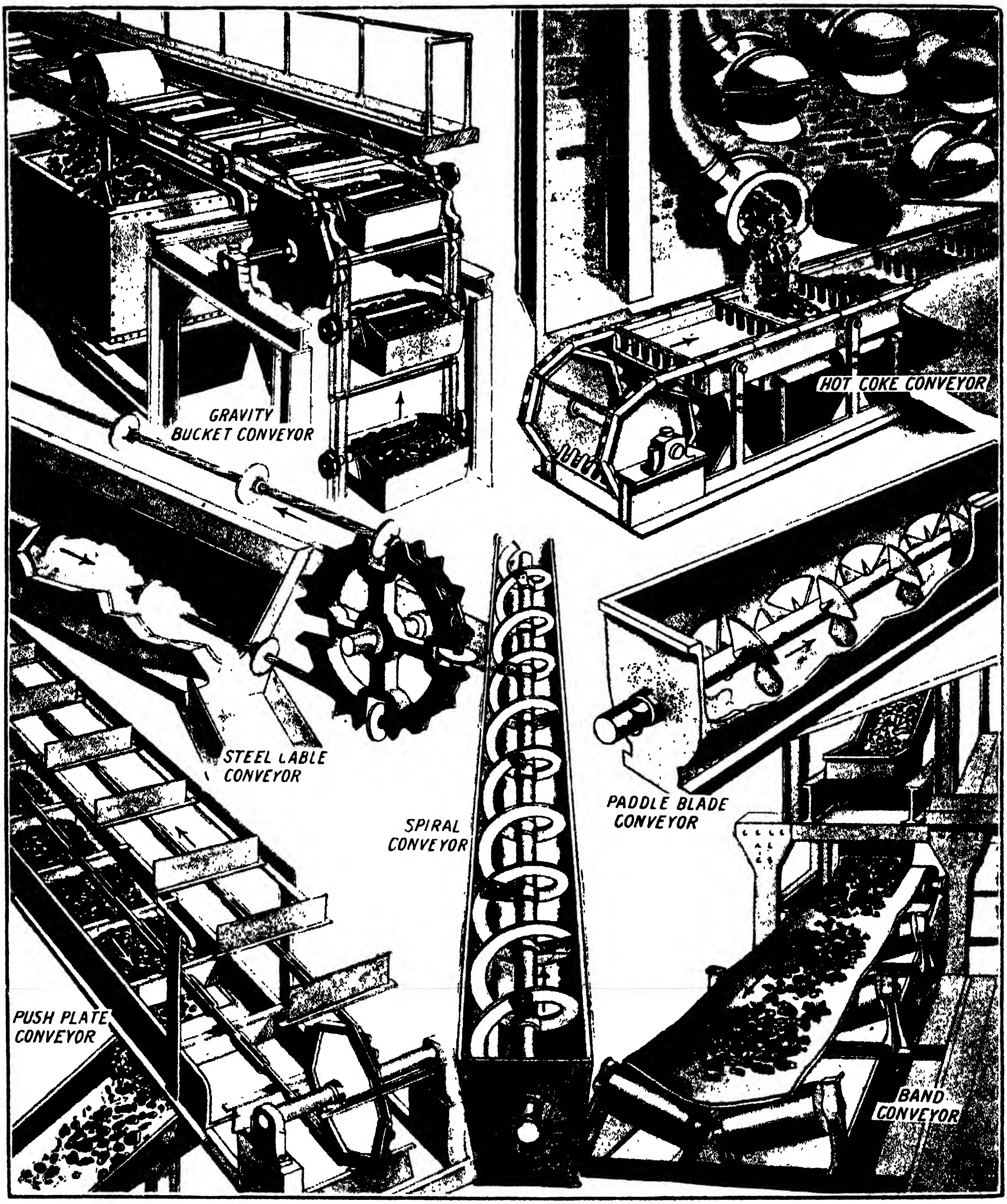
The orbits of the comets are not like those of the planets, all in one plane, but they approach the Sun at all angles and are of various shapes.

More than 1,000 comets have now been recorded, and about 400 of these were observed before the invention of the telescope. About one out of every five comets is visible to the naked eye.



A strange comet with six tails as seen from Lausanne in March, 1744. It is known as Chéseaux's Comet, after its discoverer, De Cheseaux

ALL SORTS AND CONDITIONS OF CONVEYORS



In large factories, gasworks and other scenes of industry goods are not now wheeled from place to place in trucks as was formerly done, but are carried by mechanical devices known as conveyors. These are of many types suited to the carriage of various kinds of materials. The bucket conveyor, for example, which can also serve as an elevator, is largely used for conveying coal into a boiler house and then returning with clinker and ashes. The coal is unloaded at the required point by means of a tilter, which turns the bucket as it passes. A push plate conveyor, which has a series of plates on an endless chain, is also useful for moving coal or coke. The steel cable conveyor in which discs are arranged on a moving cable, is useful for moving powder or granulated material. The paddle blade conveyor not only moves the material but mixes it or turns it over for drying. Spiral conveyors are used for transporting coal, mineral or grain the spiral pushing the material forward as it rotates, and the band conveyor will carry almost anything

MARVELS of MACHINERY

MOVING GOODS RAPIDLY IN FACTORIES

With mass production going on in our factories and works, it is necessary that the raw material and goods should be moved to and from the workmen as rapidly as possible and this is now done in all big factories by means of mechanical conveyors. Motor works, jam factories, gas-works, steel works, and so on, all use these ingenious conveyors and here we read something about them

One of the great features of all large factories and industrial organisations to-day is the rapid moving of the materials and goods from place to place during the process of manufacture and the continuous conveyance of the finished articles to the place of storage or the trains or lorries which are to carry them away.

For this purpose what are known as conveyors are used, and these are as varied in form almost as the goods they are to carry. They are among the greatest triumphs of the engineer and can be constructed to suit all kinds of goods, whether these be molten metal, steel bars or castings, parts of locomotives or motor cars, coal or coke, flour or other powdered material, glass jars or bottles, boxes or indeed any form of goods, heavy or light, massive or brittle, large or small.

Not only can the goods be conveyed mechanically from one part of a factory to any other part that is on the same level, but the conveyor can be so constructed that at a given point it moves upward, and without any additional handling of the goods can carry them to higher or lower floors for further treatment or storage there.

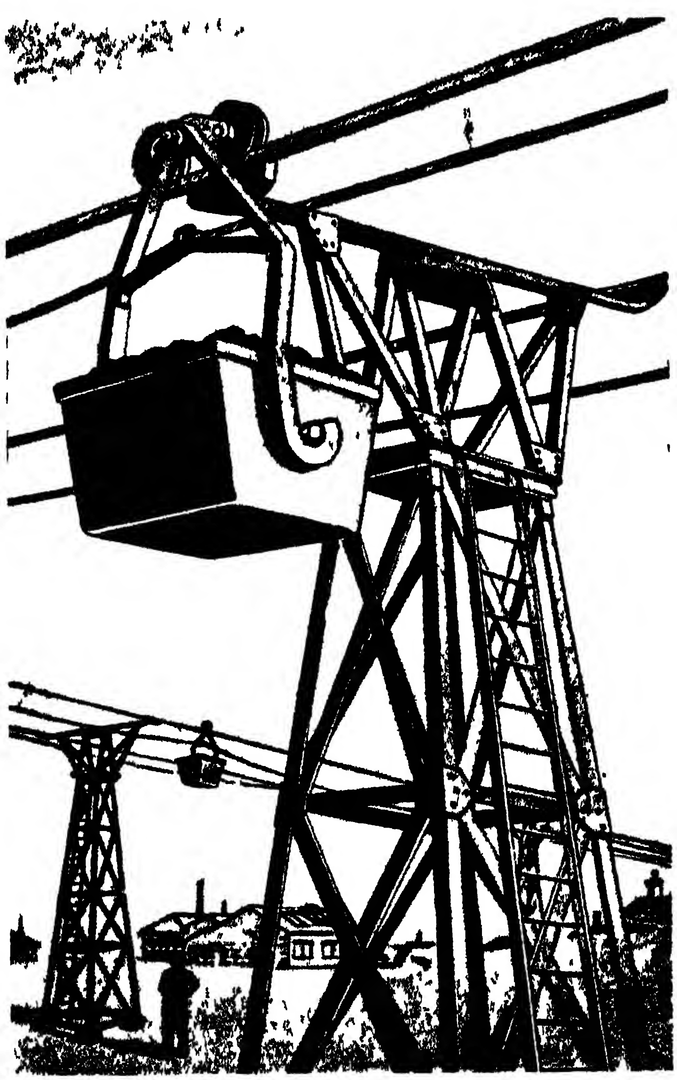
The Earliest Conveyors

It is not known exactly when conveyors first came into use. There are drawings and descriptions of devices of this kind dating back to the opening years of the nineteenth century, but it is quite likely that they remained as inventions on paper and were never actually constructed, for in those days mass production had not begun, and there was little use for any more rapid handling of goods than could be carried out by men pushing trucks and trollies.

Perhaps one of the earliest uses of conveyors was in the famous Union Stockyards at Chicago, where millions of animals are slaughtered for food every year, and where it has long been the boast that everything was used but the squeal. Here for half a century or more the animals dealt with have passed through the various operations as a continuous process, being passed on from one workman to another by means of mechanical conveyors.

With the enormous development of manufacturing machinery in practically every industry the need for rapid conveyance of materials and goods from place to place in the factory became urgent. If the very costly modern machinery is to be made to pay it must be kept working without break, and in order that this may be accomplished the workers must be supplied continuously with material and must have the products of their industry conveyed away rapidly to the department that will carry out the next operation in the process of manufacture.

The result of this need has been the invention and construction of conveyors of every possible description. Some consist of endless bands passing continuously in one direction, others of rollers on ball bearings arranged on a slanting way or in a spiral so that goods will pass along by gravitation, others of endless chain fitted at intervals with forks or plates to push on the coal, coke or other material, others of buckets or spirals or paddle blades or discs on moving steel cables, and so on. The engineers can now design and construct conveyors for any situation and any class of goods.



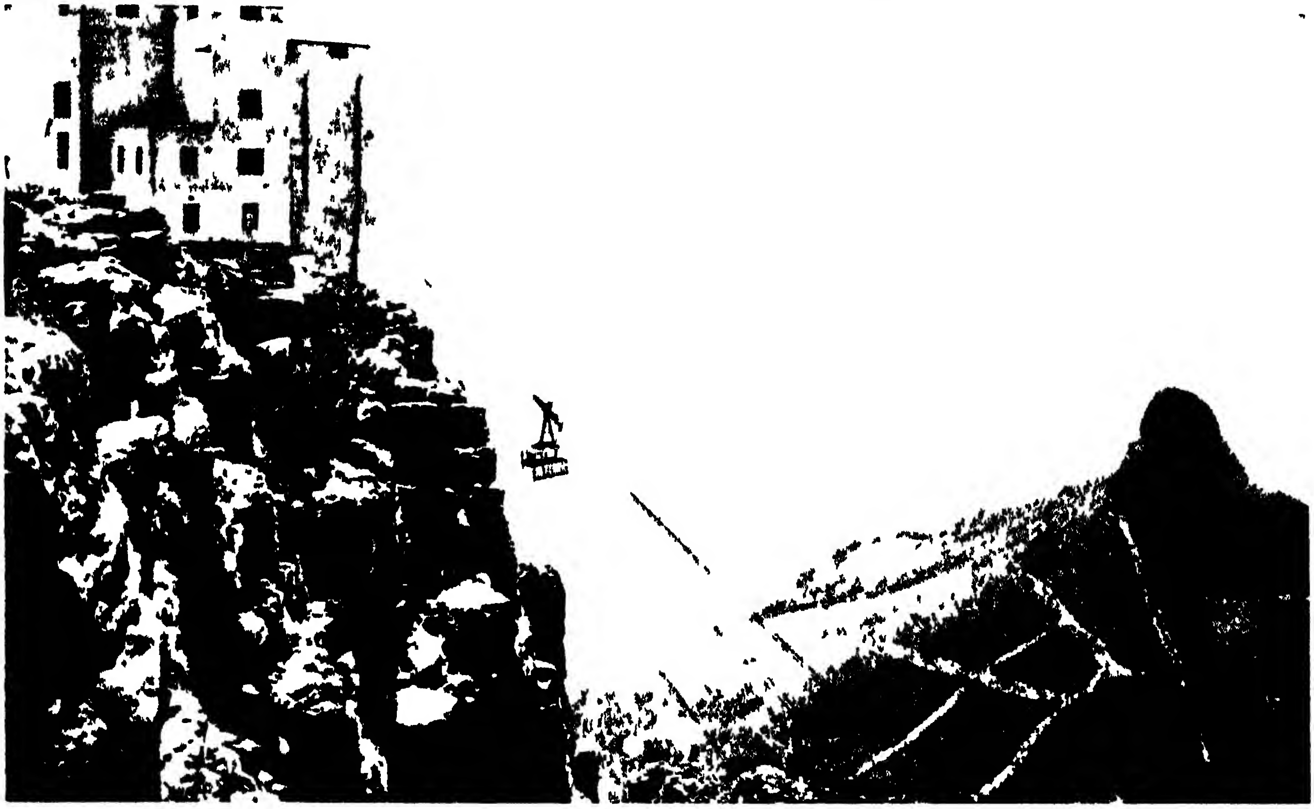
How the buckets of an overhead outdoor conveyor or aerial ropeway, such as is used in the Kent coalfield, passes the arm of a supporting trestle. The grooved wheels fit tightly over the rope

Conveying the Cars

Perhaps it is in the mass production of the modern motor car that the use of the conveyor has been brought to perfection. Here from beginning to end the cars and their parts pass by conveyor to the various workmen, each of whom does his bit, the apparatus then carrying the car on to the next man.

In one big motor works the engines are carried nearly two miles by conveyor from one building and across the top of another to the department in which the engine will be fitted to the chassis. Many factories have as much as ten miles of conveyors for the rapid moving of materials and goods. Even men and women use conveyors in the form of aerial railways and moving platforms

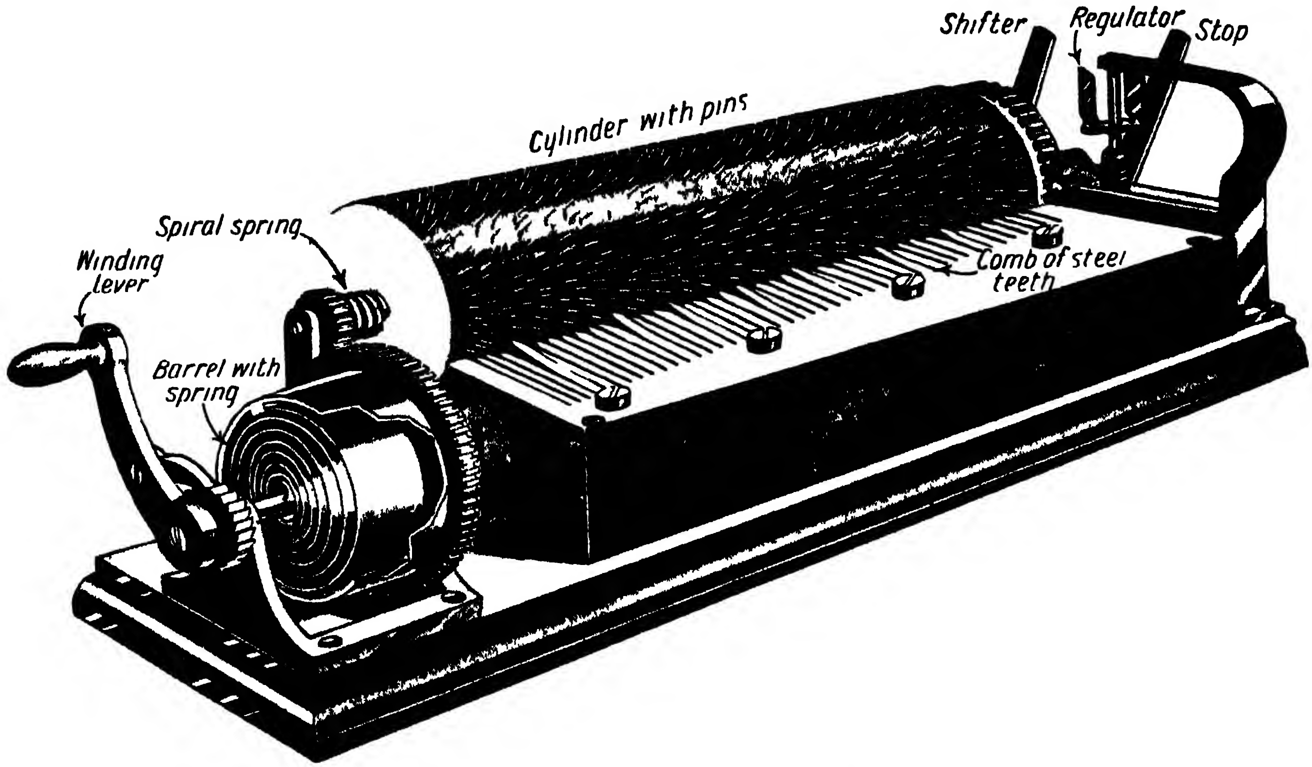
AERIAL ROPEWAYS FOR CARRYING GOODS



Aerial ropeways are exceedingly useful devices for conveying goods or even passengers across difficult and inaccessible country. They are found in mountainous districts where mining operations are carried on, as in the Andes of South America, and are the most inexpensive of all means of transport for such regions. Here is an aerial cableway on Table Mountain in South Africa

This is the aerial ropeway in the Kent coalfields for conveying the coal across country to the port for shipment. It is a very efficient system on level territory and is equally suitable where the goods have to be conveyed up or down over miles of rocky and difficult hill country. There was a great outcry when the Kent cableway was constructed, but if coal is to be mined it must be transported

HOW A MUSICAL-BOX MAKES ITS SOUNDS



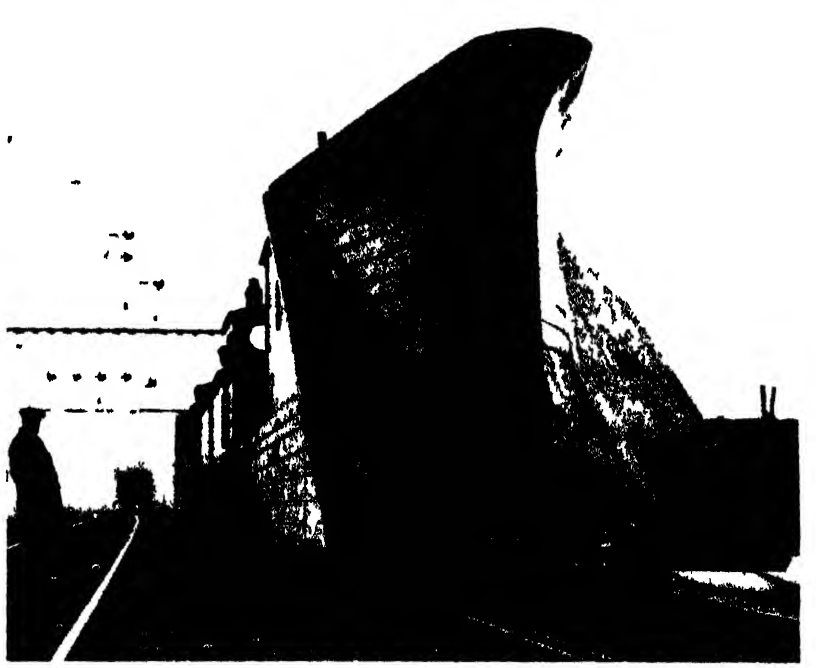
We do not see or hear musical boxes so often as we used to do because the gramophone and the wireless have pushed these ingenious instruments into the background It is interesting however to see how the old musical-box works There is a steel plate like a comb with teeth which forms a kind of keyboard, and when these teeth are struck at the end by a series of pins projecting from a cylinder, they give forth the various sounds which make the music The cylinder is set in motion by a spring and cogwheels, the spring being wound up by a lever It is really a kind of clockwork arrangement At the opposite end of the cylinder is a device for shifting the cylinder to right or left thereby changing the tune There is also a stop and a regulator to vary the speed The pins are so arranged in the cylinder as to touch the necessary teeth to give forth certain notes and one cylinder may play half a dozen or more tunes

THE SNOW-PLOUGH THAT CLEARS THE RAILWAY TRACK

Snow is the enemy of the railways but fortunately in the British Isles it is not often that a line is snowed up and generally the deposit of snow on the track can soon be removed by means of a snow plough

In America and Scandinavia where very heavy falls occur and where the snow may drift till it buries the track to a depth of perhaps fifteen or twenty feet a very different type of snow plough is required from that used in Great Britain

In these lands of heavy falls the snow plough is on the principle of a rotary digger In front is a series of scoops arranged in the form of a disc and two or three powerful engines push the snow plough up to the snow when the disc is set whirling and cut into the snow throwing it to a considerable distance in all directions



Type of snow-plough used to clear railway tracks in Great Britain

In the British Isles the type of snow plough used is shown in the picture It consists of a wedge shaped device which is pushed forward by powerful engines and divides the snow driving it to the sides of the track much in the same way as the share of a plough cleaves the soil and turns it over to the side

Of course snow ploughs are needed more in Scotland in winter than in the South of England.

THE BUOYS THAT WARN THE MARINER

In addition to lighthouses, lightships and beacons, there are round the British coasts more than a thousand buoys which mark rocks and shoals and warn and guide the mariner so that he may navigate his ship safely in dangerous places. This number does not of course include the many mooring buoys to which craft can make fast, as they are not regarded as "sea marks" like the others.

Rocks and shoals in the neighbourhood of land have always been a peril to ships, and it is to indicate the safe channels by which vessels may approach port that the buoys are moored. At the mouths of rivers like the Thames, Mersey, Humber, Tees and Severn there are many shoals and sandbanks, while on the north and east coasts of Scotland and on the West of England are countless reefs and rocks, hence the need for buoys. Pilots rely on these for help in guiding ships through the narrow channels of deep water to a safe haven.

The earliest buoys were simply wooden casks, but it soon came to be recognised that a buoy to do its work efficiently must be something more than this, and soon specially adapted constructions were built which would resist the buffetings of wind and water and at the same time keep afloat.

First the buoys were made of wood with iron hoops surrounding them to keep their staves in position, but now they are all of iron and are in many cases quite elaborate machines. Different types of buoys are used for different purposes, their shapes, markings and colours indicating the services they are intended to perform.

The channel or "fairway," as it is called by seamen, into a port or river is generally marked by a double line of buoys. Those on the starboard side as a ship goes in are conical in shape and painted one colour, either red or black, while those on the port side are flat topped and are known as can buoys because they are like a can. These are painted with a check pattern. Dangers in the middle of a channel are generally marked by a spherical buoy painted with rings or stripes and carrying a pole or staff with a mark on top—a diamond if it is the outer channel and a triangle if it is the inner channel. Special buoys are used to mark wrecks.

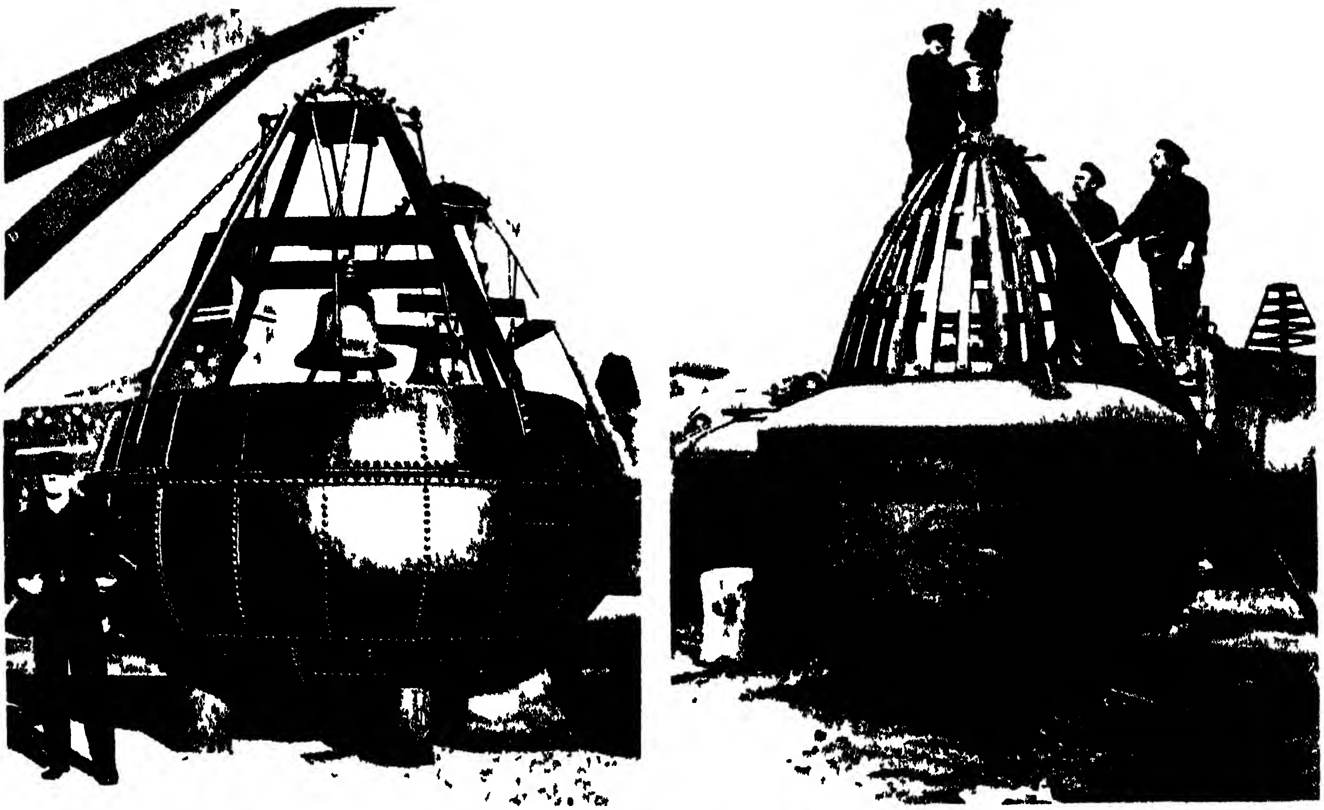
It is however the huge bell buoys and light buoys that are the latest developments in construction and are worthy to be described as machines. Some have both a bell and a light and others have an automatic whistle.

In the bell buoys the bell weighing about three hundredweights is fixed in an iron framework, and four hanging clappers round the outside of the bell strike it alternately as they are swung by the movement of the waves. An incessant tolling is thus maintained and is very useful at night and in foggy weather, but the distance the sound carries varies with the weather.

The whistling buoy has a tube 33 inches in diameter and 32 feet long passing through its centre and descending 20 feet into the water. The bottom of the tube is open and admits a column of water which is not affected by the wave motion on the sea's surface. The rounded buoy however moves with the waves carrying the tube up and down with the result that the column of water in the tube acts like a piston and compresses the air which passes through valves into a smaller pipe and blows a whistle at the top.

The automatic light buoys have a store of compressed gas or a stock of carbide from which acetylene gas is made at a regular rate to supply the light.

A recent development of navigation buoys is the radio beacon buoy for helping a ship to fix its position. These are fitted with short-wave radio transmitters which automatically broadcast specific signals.



These photographs show two of the giant buoys which are now used for marking reefs and shoals. They are really elaborate machines carefully constructed on scientific principles. The one on the right is a gas buoy in which the buoy itself contains the supply of gas which is fed to the burner automatically and keeps the light shining. We sometimes hear a warning given on the wireless that the light of such and such a buoy has become extinguished. This may occur from a variety of reasons, and the buoy is then generally removed for overhauling. On the left we see a giant bell buoy, which has been taken from the water for repainting and overhauling. The bell is tolled continuously by the regular movement of the waves.

THE GREATEST BOOK IN THE WORLD

The Authorised Version of the Bible has been called "the Greatest Book in the World," and "the Greatest English Classic," and both descriptions are true. Many scholars contributed to give us this magnificent monument of truth and beauty, and each worked for sheer joy of the task, and not for pay. It has been very aptly said that the men who made the translation were more than scholars, they were artists, using the word in the sense in which it is used when one speaks of an orchestra, and they used their instrument, the English language—with studied skill. The great ideas of the original were wedded to worthy expression in the translation. Here is the great story of the English Bible and how it has come down to us

In Queen Victoria's days many British homes had hanging on their walls a large engraving of a painting entitled "The Secret of England's Greatness." The picture showed Queen Victoria presenting a copy of the Bible to an African chief, and the story told in connection with it was this. An African chief once wrote to the Queen asking her what was the secret of England's greatness, and in reply it is said she sent him a beautifully bound copy of the English Bible.

Whether the incident actually occurred or not the picture was certainly a parable with a great deal of truth in it. England owes much to the fact that for nearly 400 years the Bible in the mother tongue of the people has been available to all.

The high standard of morality and the integrity of public life which have been at any rate the ideal of Englishmen have been largely due to the fact that the truths and maxims of the Bible have been familiar to all.

Further, the fact that the English language has remained practically unchanged for more than three centuries must be attributed to the English Bible, which has been in the hands of the people. It fixed and unified the language and saved it from changing as many continental languages have changed where there was no similarly stable standard of uniformity.

Moulding the Language

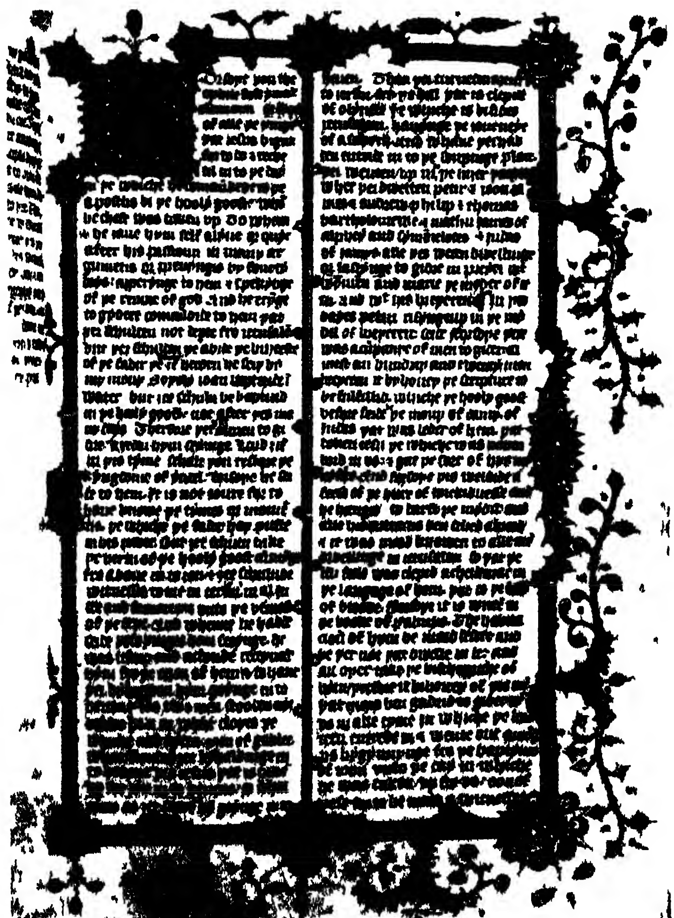
Two other books assisted in moulding the language, though their part was not so great as that of the English Bible. One was the Book of Common Prayer, whose beautiful language we largely owe to Archbishop Cranmer, and the other was the first folio of Shakespeare, who wrote his popular plays in the same language as the Bible of the people.

The story of the English Bible is a romance which all should know, and honour should be done to the great and good Englishman to whom the clearness and beauty of the translation is almost entirely due. This man was William Tyndale, and he may almost be described as the fixer of the English language.

Of course, the Bible of the people since the year 1611 is the version which we still use, and is known as the Authorised Version, though so far as history record it was never authorised by King, Parliament, or Bishops, but simply won its way in the affections of Englishmen by the sheer beauty and merit of its language.

But anyone who takes the trouble to compare the Authorised Version of the New Testament with Tyndale's translation made in the sixteenth century will find in most cases the wording identical. Later compilers and editors of English editions of the Bible were rarely translators in the true sense of the word. They merely took Tyndale's translation and reprinted it with slight alterations.

This being so, it is one of the saddest facts in English history that this great and good man should have died a martyr for the very work that within a few years was recognised by King and Church and people, and has ever since been praised and honoured as a wonderful task well performed.



A page from Wycliffe's Bible, the first complete Bible in the English language. It was completed about 1382

The First Printed Book

The Bible in its Latin form known as the Vulgate was the very first book to be printed from movable type in any European country, and a magnificent piece of work it was. That was about 1450. It was three-quarters of a century later before an English translation of any part of the Bible came to be printed, and then it was produced not in England but at Cologne in Germany. It was a New Testament, and though several editions of the complete Bible were afterwards printed and put into circulation, these were all produced on the Continent, and not till 1536 were copies of the English Bible actually printed in England.

The English printed Bible came as the result of a real demand on the part of the people. Long before it had been printed, however, the Bible had been translated into English, and even in Anglo-Saxon times a small part was translated for reading,

though of course there could have been no great demand in days when few persons outside the Church and the monasteries were able to read at all

It was the Venerable Bede who translated the Gospel of St John into Anglo Saxon and only just completed the work as he died at Jarrow Monastery Cuthbert one of his disciples tells us the touching story

Through the whole of the eve of Ascension Day in the year 735 the old monk the greatest scholar in Europe dictated his translation His strength was gradually giving way and when evening came he was very weak Then at night there still remained one chapter untranslated

Most true master said his followers there is one chapter yet to do

Then take your pen said Bede and write quickly

His spirit was very willing although his flesh was getting weaker and weaker The brethren of the monastery entered the room one by one weeping to bid their last farewells Once again darkness fell but the work was almost done The little scribe who was taking down the translation bent down and whispered in the dying saint's ear

Master even now there is one sentence more

The Work Finished

Write on fast whispered Bede and the boy wrote Then he cried 'See dear master it is finished now

Ye murmured the dying saint you speak well it is finished now Take my head into your hand and lay me down opposite the holy place where it was my wont to pray And on the pavement of the little cell they laid the aged monk down who whispering the Gloria gave up his spirit

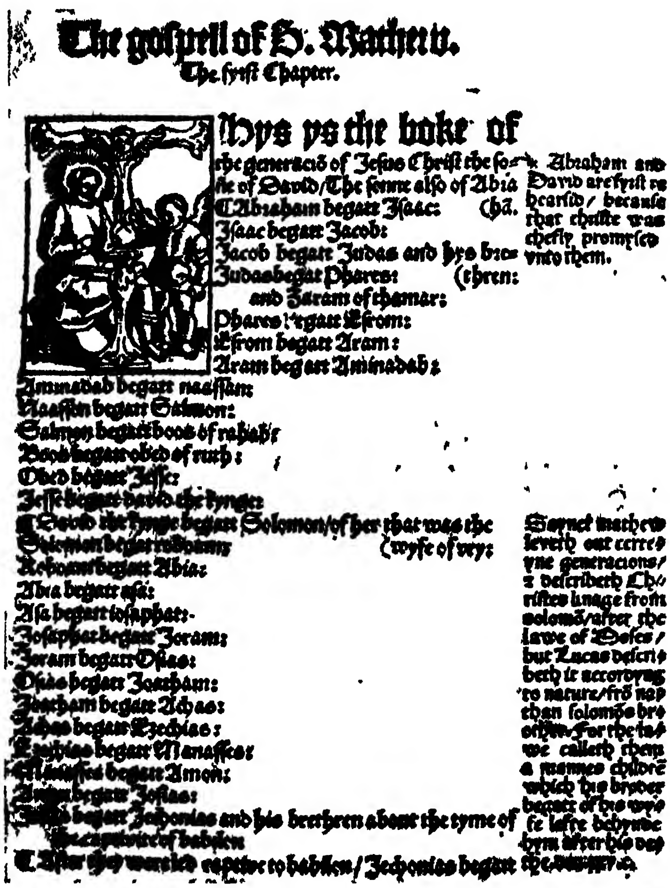
We do not possess his translation of the Gospel but no doubt it was read to many in the days that followed

John Wycliffe however was really the first translator of the Bible into English for the people It is very different English from that which we speak and write now but it was the language of the people of his day Because it was the ordinary familiar language of the people some disliked it

This Master John Wycliffe wrote one 'translated into the Anglic not an Angelic tongue the Gospel Whence it is made vulgar by him and more open to the reading of lay men and women than it usually is to the knowledge of lettered and intelligent clergy and thus the pearl is cast abroad and trodden under feet of swine The jewel of the Church is turned into the common sport of the people "

Wycliffe's Bible as it is often called is really a translation of a translation, for he did not use the Greek New Testament and the Hebrew Old Testament but the Latin Vulgate edition which St Jerome had made in the fifth century

While it is difficult to read Wycliffe's Bible to day there are many phrases in it which appear in the Authorised Version our present day Bible Among these may be mentioned 'Strait gate' Make whole 'Son of perdition


The gospell of S. Mathew.
The fyrst Chapter.

Thys ys the boke of the generació of Jesus Christ the sonne of David/The sonne also of Abra
Abraham begatt Isaac:
Isaac begatt Jacob:
Jacob begatt Judas and hys brethren:
Judas begat Phares:
and Zaram of thamar:
Phares begatt Efrom:
Efrom begatt Aram:
Aram begatt Aminadab:
Aminadab begatt naasson:
Naasson begatt Salmon:
Salmon begatt boos of rahab:
Boos begatt obed of ruth:
Obed begatt Jesse:
Jesse begatt david the kynge:
David the kynge begatt Solomon/of her that was the wyfe of ury:
Solomon begatt roboam:
Roboam begatt Abia:
Abia begatt asa:
Asa begatt iosaphat:
Josaphat begatt Joram:
Joram begatt Osias:
Osias begatt Joatham:
Joatham begatt Achas:
Achas begatt Ezechias:
Ezechias begatt Manasses:
Manasses begatt Amon:
Amon begatt Josias:
Josias begatt Jechonias and his brethren about the tyme of the captivite of babilon
After they wer led captive to babilon/Jechonias begatt

Abraham and David are fyrst rehearsid/ because that christe was chefly promysed unto them.

Saynct mathew leveth out certayne generacions/ & describeth Christes linage from solomó/after the lawe of Moses/ but Lucas describeth it accordyng to nature/fró nathan solomós brother. For the lawe calleth them a mannes childré which his brother begatt of his wyfe lefte behynde hym after his deth.

A page from the only known fragment of Tyndale's New Testament, printed at Cologne in 1525 The first ten sheets had been printed when Tyndale was obliged to flee to Worms, and there begin work afresh

Compass land and sea ' ' Enter thou into the joy of thy Lord '

Wycliffe was the first Englishman to have the idea of translating the whole of the Bible into his mother tongue and he himself translated the New Testament while a friend of his named Hereford at Oxford, set to work on the Old Hereford's task was cut short by the Church authorities, but the work was completed, probably by Wycliffe himself Anyway, the whole Bible was turned into English and though copies could only be multiplied by handwriting and each one cost something like £30 of our money, yet a considerable number of Bibles was produced and no doubt eagerly read

Wycliffe's Bible was completed about 1382 but it was nearly 500 years later that is 1850 before it was actually printed

In order to see how different Wycliffe's Bible is from that which we use to day we may give here his version of the well known 23rd Psalm

The Lord gouerneth me and no thing schal faile to me , in the place of pasture there he hath set me He norischide me on the watir of refreischyng he conuertide my soule He ledde me forth on the pathis of rightfulnesse for his name For whi though Y schal go in the myddis of schadewe of deeth Y schal not drede yuels for thou art with me Thi gherde and thi staf tho han coumfortid me Thou hast maad redi a boord in my sight aghens hem that troblen me Thou hast maad fat myn heed with oyle and my cuppe fillinge greeth is ful cleer And thi merci schal sue me in alle the daies of my lijf And that Y dwelle in the hows of the Lord in to the lengthe of daies

William Tyndale

The history of the printed English Bible begins with William Tyndale of whose early life we know nothing He was born about 1500 in a little Gloucestershire village on the borders of Wales He went to Oxford University and studied languages so well that he became proficient in several including in addition to his mother tongue Latin Hebrew Greek Italian French and Spanish It was said that whichever he spoke you would suppose it his native tongue ' Later, he learnt German He also studied the Bible very closely

After he had finished his studies at Oxford he returned to Gloucestershire for about two years as private chaplain to a knight and then came to London

He was mixed up in many controversies but through them all he determined as soon as he could find an opportunity, to translate the Bible into English Once, in an argument with a learned ecclesiastic, he made the famous declaration, " If God spare my life, ere many years I will cause a boy that driveth a plough shall know more of the Scripture than thou dost "

With this purpose in mind, he went to London and tried to enlist the sympathy and help of Tunstall, Bishop of London To show that he was

capable of translating from Greek, he took with him a speech of Isocrates, the Athenian orator, which he had translated. But the Bishop was cold and unsympathetic. He stated that his house was full, and he could not find room for Tyndale.

The scholar thereupon found a friend in an alderman of London, Humphrey Munmouth, who was afterwards imprisoned in the Tower because of his kindness to Tyndale.

All sorts of difficulties were put in Tyndale's way, and he tells us: "In London I abode almost a year, and marked the course of the world, and understood at the last that not only was there no room in my lord of London's palace to translate the New Testament, but also that there was no place to do it in all England."

Tyndale was a persistent and determined man, and he therefore decided to go abroad in order to carry out his life's work. So, in May, 1524, he went to Hamburg. We do not know how much of his work of translation had been done before he left England, but by the early summer of 1525 the New Testament was ready for the printer. That he was well qualified for the work, even his enemies declared, testifying that "he was well known for a man of right good living, studious and well learned in scripture."

First of all, the Gospels of St. Matthew and St. Mark were printed separately at Hamburg. Then Tyndale went to Cologne, where the first complete translation of the New Testament was produced. After ten sheets had been printed, the expense being defrayed by English merchants, an enemy informed the authorities of the city, and the work was stopped. But Tyndale carried the printed sheets to Worms by ship, and the work went on, two editions of the New Testament being prepared, one large in size and the other small.

The authorities in England who had received information of what was going on, became alarmed, and Henry the Eighth was warned by his almoner, Lee, afterwards Archbishop of York, that it was dangerous for these books to be circulated. "All our forefathers," says the almoner, "governors of the Church of England, have with all diligence forbid and eschewed publication of English Bibles."

However, Tyndale's testaments arrived and were eagerly bought, but their sale and possession were forbidden, and they were sought out keenly for destruction. Sir Thomas More quite unfairly attacked the translation as ignorant and dishonest, which it certainly was not. Tunstall, the Bishop of London, attacked it in a sermon at Paul's Cross. When other means failed, copies were bought up and burned both on the Continent and in England, but this only stimulated the sale. By 1530 six editions had been published and sold.

Tyndale realised the risk he took, for he says, "In burning the New Testament they did none other thing than I looked for; no more shall they do if they burn me also, if it be God's will it shall be so. Nevertheless, in translating the New Testament, I did my duty, and so do I now."

William Tyndale at work translating the New Testament. From the painting by Johnstone

There must have been 15,000 copies of Tyndale's Testament printed in the first year or two, but so fierce was the hunt for them, and so constantly were they being found and destroyed, that to-day only two or three incomplete fragments remain. People who were discovered with copies of the Testament were compelled themselves to throw the books publicly into fires kindled for the purpose.

Tyndale went on with his work. He published separately translations of Genesis and Deuteronomy, and then all the books of the Pentateuch in one volume. Three years later the book of Jonah was issued.

The demand for the New Testament became ever greater, and some unauthorised editions with corrections by another man, George Joye, but entirely without Tyndale's sanction, were issued. This made Tyndale determined to revise his own Testament, and for this purpose he studied Greek afresh. When the revised translation was ready a copy was struck off on vellum and presented to Queen Anne Boleyn under whose favour a reprint of the revised New Testament was produced in England two years later, the very first copy of the scriptures to be printed in this country.

Now came the tragedy of Tyndale's life. He was treacherously betrayed to the authorities at Antwerp by a false friend, Henry Philips, who turned out to be a thief that had fled to Flanders after robbing his father.

Tyndale was at once seized and carried off to the prison of Vilvorde Castle, near Brussels. The English merchants declared that the arrest was a breach of their privileges and they tried to get Henry the Eighth and Thomas Cromwell to make a protest, but for political reasons there was no intervention, and after about eighteen months Tyndale was brought to trial for heresy and strangled at the stake, his body afterwards being burned.

He had not lived to complete the translation of the entire Bible. During his life the New Testament, Pentateuch, and Book of Jonah, together with the Epistles for the week from the Old Testament, had been published, and he left behind in manuscript a translation of eight or nine other books of the Old Testament, all completed while in prison.

There is a pathetic letter in Latin addressed by him to the Governor of the Castle, in which he begs for warmer clothing, and adds, "I wish also for permission to have a candle in the evening, for it is weary work to sit alone in the dark. But above all things, I entreat and beseech your clemency to be urgent with the procureur that he may kindly suffer me to have my Hebrew Bible, grammar and dictionary, that I may spend my time with that study." That the prayer was granted

is almost certain, owing to the existence of translations of the Old Testament from Joshua to the end of Chronicles, which must have been made in prison.

At the time of his death not far short of 50,000 copies of his translations had been issued from the Press.

Tyndale was gone, but the demand for an English Bible continued, and with the co-operation of Thomas Cromwell, Miles Coverdale produced the first complete English Bible that had yet been printed. It was dedicated to Henry the Eighth in rather fulsome terms, and was allowed to circulate, but it went forth without any distinct royal sanction.

Various Editions

Coverdale used Tyndale's translations as far as they went, and filled up the gaps himself. The first edition of his Bible was soon exhausted, and in the same year another Bible which is known as Matthews' Bible, from Thomas Matthews, who helped John Rogers, a London rector, to produce it, was printed abroad. This used all Tyndale's translations, including the Old Testament from Joshua to Chronicles, which had not yet been printed, completing the work from Coverdale's translation.

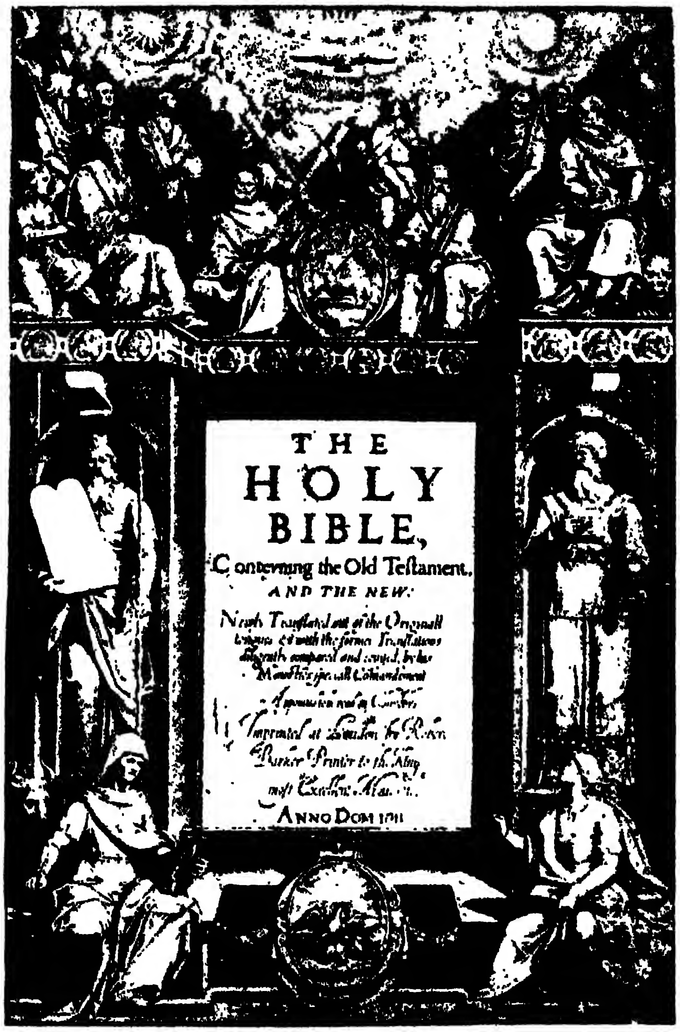
It was sanctioned by the King, a fact which, but for the tragedy of Tyndale's end, might make us smile, for two thirds of Matthews' Bible was actually the work of Tyndale, who had been put to death with the tacit approval of Henry for that very work.

There were now two Bibles circulating with official sanction, namely Coverdale's and Matthews', but it was felt that neither was quite satisfactory, and so in 1538 Coverdale was asked to undertake the preparation of a new edition based on Matthews', but with a more critical examination of the Hebrew and Latin texts.

He carried out the work, and he and an associate named Richard Grafton went to Paris to arrange with the great French printer Regnault, to print the Bible under special licence from King Francis.

Things were going well when, suddenly, the Inquisitor-General stepped in and issued an order to confiscate the sheets. Four vats of printed matter were sold as wastepaper to a haberdasher, but he resold them to Thomas Cromwell's agents, and they were sent over to London secretly. Coverdale and Grafton had already fled from France, and Cromwell afterwards bought type and presses from Regnault and obtained the services of a staff of skilled compositors to complete the work in England.

The presses were set up in London, and in 1539 the first edition of what came to be known as the Great Bible was issued. It was a large folio volume in black letter, and was really the only formally authorised English Bible that has ever been issued.



The title page of the first edition of King James's Bible, printed in 1611, and known ever since, though incorrectly as "the Authorised Version." It is also called the "Great He" Bible

People Flock to the Reading

It was set up in churches and the people flocked to hear it read. In fact, so anxious were the people to hear it that often the reading went on at the same time as the church services, and warnings had to be issued that this must stop or the Bibles would be removed.

Strype tells us that "It was wonderful to see with what joy this Book of God was received not only among the learneder sort and those that were noted for lovers of the Reformation, but generally all England over, among all the vulgar and common people; and with what greediness God's word was read and what resort to places where the reading of it was. Everybody that could bought the book or busily read it, or got others to read it to them if they could not themselves, and divers more elderly people learned to read on purpose. And even little boys flocked among the rest to hear portions of the Holy Scripture read."

No new version of the English Bible was attempted in Edward the Sixth's reign, but after Mary had come to the throne a number of English reformers gathered at Geneva and prepared a new English version of the Bible, which is called the Genevan Bible. It has also been given the name of Breeches Bible, because in Genesis III, 7, the translation reads, "And they sewed fig leaves together and made themselves breeches" Our version, of course, translates the word as aprons.

A Handy Volume

This Genevan Bible, which was really a revision of Tyndale, became tremendously popular chiefly on account of its convenient size. It was a comfortable quarto volume, whereas the authorised Great Bible was a very unwieldy folio The men who prepared this Genevan version were opposed to most of the popular forms of recreation and amusement, and we see this coming out rather curiously in their heading to St Mark's account of the murder of John the Baptist. He was beheaded, it will be remembered, at the request of a dancing girl, and the translators placed at the head of the story the words, "The Inconvenience of Dauncing."

Queen Elizabeth was not anxious to take sides with either the Puritan or Catholic element in her realm, and therefore Convocation could hardly expect to get her sanction for the Genevan Bible It was felt, however, that a new official edition was needed, and so instructions were given to a committee to prepare a new version which came to be known as the Bishops' Bible. The revisers were instructed to keep to the Great Bible except where it varied manifestly from the originals. After four years this Bible was ready, and it superseded the Great Bible in churches, but it was both cumbersome and costly, and had many defects. Queen Elizabeth's portrait

appeared on the title page, but she never authorised it.

At last, after James the First came to the throne, a real attempt was made to produce an English Bible which should commend itself to all.

Scholars to the number of 47 were appointed and divided into six companies, two of which held their meetings at Oxford, two at Cambridge, and two at Westminster. Men of all shades of opinion were represented, and they were instructed to consult every version, whether English, Latin, French, Italian, German or Spanish, which they found in circulation, as well as the original Greek and Hebrew documents. They were told that the Bishops' Bible was to be followed, and as little altered as the truth of the original would admit.

The Authorised Version Appears

At last, in 1611, the new version of the English Bible was issued in black letter. It is described on the title page as a 'translation' and bears the words, 'Appointed to be read in churches,' but so far from being a translation, it was merely a revision, and there is no evidence to show that there was ever any formal appointment of it for use.

But it soon superseded all other versions by its sheer merit, and for that merit William Tyndale must be thanked, though Coverdale contributed something. The scholars tell us, 'Truly we never thought to make a new translation, nor yet to make of a bad one a good one, but to make a good one better, or out of many good ones one principal good one." They certainly achieved their purpose.

Nine-tenths of the so-called Authorised Version consists of Saxon words. In Shakespeare the proportion of Saxon words is only 85 per cent. In the Lord's Prayer 59 words out of 65 are of Saxon origin.

The Father of the English Bible

A distinguished authority on the English Bible, Mr. H. W. Hoare, describes Tyndale as 'The true father of our present English Bible," and he estimates that of Tyndale's work our Bibles retain at the present day something like 80 per cent. in the Old Testament and 90 per cent. in the New.

"If this estimate may be accepted," he says, "no grander tribute could be paid to the industry, scholarship and genius of the pioneer whose indomitable resolution enabled him to persevere in labours prolonged through twelve long years of exile from the land that in his own words, he so loved and longed for, with the practical certainty of a violent death staring him in the face."

One other thing must be mentioned. In the very fulsome preface to the so-called Authorised Version of the English Bible it is suggested that the idea of preparing this version was King James's and that he "did never desist to urge and to excite those to whom it was commended that the work might be hastened and that the business might be expedited." As a matter of fact, as the distinguished bibliophile, Mr. A. Edward Newton, has pointed out, the idea of making the new edition was not James's and so far as is known the Scottish King did not contribute a single penny towards the undertaking.

But, whatever may be the particular share that different individuals contributed to the English Bible as we have it to-day, one thing is certain and that is that in the so-called Authorised Version we possess a great and magnificent work which, by the bond of a common literary heritage, unites together the whole English-speaking race.

The "He" and "She" Bibles

It has been said that never was so important a literary enterprise carried out with so little record thereof, and this is true. It was not entered at the Stationers' Hall like most other books, so that no one can say in what month of the year 1611 it appeared. It is supposed that two printing-houses undertook the work because there are different misprints which can only be explained in this way. There are two issues of the first edition and they are known respectively as the 'Great He' and the 'Great She' Bible from a variation in the printing of the 15th verse of the third chapter of Ruth. In one the close of this verse reads, 'He went into the citie' while in the other it is printed "She went into the citie." The 'He' Bible is most sought after by collectors.

A public reading of the English Bible in Old St. Paul's Cathedral. From the painting by Harvey. These early printed Bibles were so precious that they were chained up for safety. Few of them remain because they were mostly worn out with use

TIRED NATURE'S SWEET RESTORER

Sound and regular sleep is necessary to health. It is during sleep that nerves and muscles are at complete rest and the quieter the surroundings the better and more restful is the sleep That is why children should have plenty of sleep in silent and darkened rooms

The sleep of this child which has been resting for many hours is not so sound as the one above. Having had ample rest, it is waking of its own accord and is beginning to rub its eyes, an instinct which is one of Nature's provisions to stimulate the tear glands that have been inactive during sleep. In a few minutes the eyelids will open to let in the light and stimulate the nerves and muscles to activity

THE GREAT MYSTERY OF SLEEP

If we do not sleep we cannot keep healthy, for sleep is Nature's great restorer. While we are asleep our bodies are at rest in a way that they cannot be when we are awake, even though we may be lying down. No wonder the poet exclaims, "O sleep! it is a gentle thing, beloved from pole to pole." Science does not thoroughly understand the mystery of sleep even now, but here we may read many important facts about it

Why, after being awake for a long time, or working very hard, do we want to go to sleep? And why do we get tired about the same time every night? What, in fact, is sleep, and why after sleeping for so many hours do we wake generally about the same time?

All these are very important questions, for sleep is one of the most vital facts in our lives. The poet rightly calls it "tired Nature's sweet restorer." It is absolutely necessary if we are to keep healthy that we should have sufficient sleep, and, indeed, if we were to be kept awake by noise and other disturbances so that we could not sleep at all, we should very soon die.

What is true of us is true also of the higher animals, and even the lower ones have periods of rest corresponding to our sleep. Fishes, from time to time, go to the bottom of the aquarium or pond or river and remain still. They are sleeping, although their eyes are not closed, because they have no eyelids with which to close them. Snakes also sleep, but their eyes, too, are open, for the same reason. The mammals and birds, however, close their eyes when sleeping.

The importance of sleep is shown by the fact that when young dogs are deprived completely of sleep they die in four or five days. Older dogs if kept awake for periods of thirty hours or more seem as though they were intoxicated, and changes take place in the cells in the front part of their brains. When their blood is taken and injected into the brains of other animals, these at once show signs of being tired and fall asleep.

During the terrible religious persecutions in France in the seventeenth century known as the Dragonnades, the soldiers used to keep their victims awake for days and nights by beating drums loudly in their presence and making other noises which prevented sleep. Many of the victims died as a result.

Exactly what sleep is no scientist can tell us. Nor are men of science agreed as to what it is that brings on the drowsy feeling and makes us sleep. All we know is that sleep is a period of more or less inactivity, when various parts and organs of the body can get a rest and get ready for another period of activity.

It is important, of course, that our arms and legs and bodies should be able to rest after hard work. What is of far greater importance, however, is that our brains should stop working for a time, and this happens when we go to sleep.

But all the brain does not stop working. The parts that are concerned with thinking and willing and balancing and co-ordinating, or bringing our

Everyone needs a certain amount of sleep, and this varies with different people. It is important that we should get all the sleep we need, and Nature helps us to know how many hours are required, for when we have had sufficient we shall wake up without being called. If we cannot wake up of our own accord and need much rousing, we are not getting sufficient sleep. When we wake up Nature inclines us to stretch our arms, expand our chests, and open our mouths to breathe deeply, as in our waking hours we require more oxygen than when we are asleep. We also rub our eyes to stimulate the tear glands that have been inactive during sleep, and thus lubricate our eyes

different actions into proper relation with one another, all stop working partly or completely during sleep

The part of the brain, however, which has to do with breathing and the regular pumping of the blood through the body does not sleep. This, of course, is a very good thing for us. If that part of the brain were to cease working we should die.

But when we are asleep even the heart beats more slowly and the breathing is less rapid. Some of the materials that our bodies make, such as tears, and the fluid produced in the nose, diminish in amount when we are asleep. That is why we do not have to wipe our noses when we are asleep.

We do not generally fall asleep all at once A tired feeling comes on, and we begin to rub our eyes This is because the tear glands, which keep a constant stream of moisture running over our eyeballs, are slowing down in their work, and we unconsciously rub the eyes so as to stimulate these glands into producing more of the fluid

Why We Shut Our Eyes

We try to help ourselves to get to sleep by shutting our eyes. That is to keep out the light, for light stimulates the nerves of the eye and keeps the brain active.

If we are sitting up late and feel very tired, our eyelids droop This is because the nerves and muscles are getting inactive and do not respond properly to the impulse to hold up the eyelids It needs an effort to keep the eyes open, just as it does to hold the arms up. That is why the lids remain closed when we are asleep As soon as we awake and get active once more we are able to open our eyes We also generally rub them after waking to stimulate the tear glands into action.

The body when tired, owing to the slowing down of various organs, begins to produce less heat, and so when we retire in order to sleep we like the place to be warm We cover ourselves with a blanket or rug, so as to store up the reduced amount of heat which the body is producing in sleep Animals take the same precaution We know how a dog or cat curls up when it goes to sleep, so that its coat will form a blanket.

When we fall asleep the muscles cease to move, and as less heat is produced there is less carbon-dioxide gas to be breathed out.

As we go to sleep the power to make conscious movements is lost first of all, but we can still hear sounds, such as people talking in the room, or the traffic passing in the street, or a railway whistle blowing in the distance. At last we lose consciousness altogether, and even the sounds are not recognised.

The earlier hours of sleep are often referred to as "beauty sleep," as though they were of special value. This is a fact, for it has been found by elaborate experiments that the deepest sleep is reached about an hour after the beginning

Children Need Much Sleep

Children need much more sleep than grown-up people, and if they do not get all the sleep they need their health and growth suffer. One of the greatest disservices parents can do for their children is to let them sit up late. Young babies sleep most of the day, and older children require at least twelve hours of sleep regularly every day. Young men and women should have eight hours, but in old age people find five or six hours' sleep sufficient.

When we have fallen asleep and become unconscious to things around, our nerves still carry messages to the brain, although the brain does not take very much notice of the messages. A cart rattling over the stones in the street may not awake a sleeping person, but experiments have proved that the ear nerves send a message to the brain, because such a noise causes the sleeper's pulse to quicken somewhat. If we gently tickle the face of a sleeping person, or if a fly settles on his nose, a message will go to his brain, and though he will not wake, his hand will be raised to remove the disturbing object. Sometimes a sound will cause the sleeper to dream, showing that some part of his brain is partly active.

It is believed by some scientists that the size of the brain diminishes slightly during sleep, while the feet and hands get a little larger. This is believed to be due to the fact that a certain amount of blood leaves the brain in sleep, and that it finds its way to the extremities.

Now what is it that makes us "ready for bed" at more or less regular periods ?

Some have thought that during the waking period certain acid substances were produced in the body which dulled the sensitiveness of the nerves and brain. Others, that oxygen stored up in the cells of the body during sleep is used up during the waking hours more rapidly than fresh oxygen is formed, and so the blood having less oxygen than it needs, is unable to do its duty properly, and so affects the brain. Then some believe that sleep is caused by the cells of the nerves contracting slightly, so that the continuous path of the nerves is broken.

Another theory is that a special toxin, or poisonous substance, is formed during the waking hours and accumulates in the cells of the brain, causing them to cease their activity

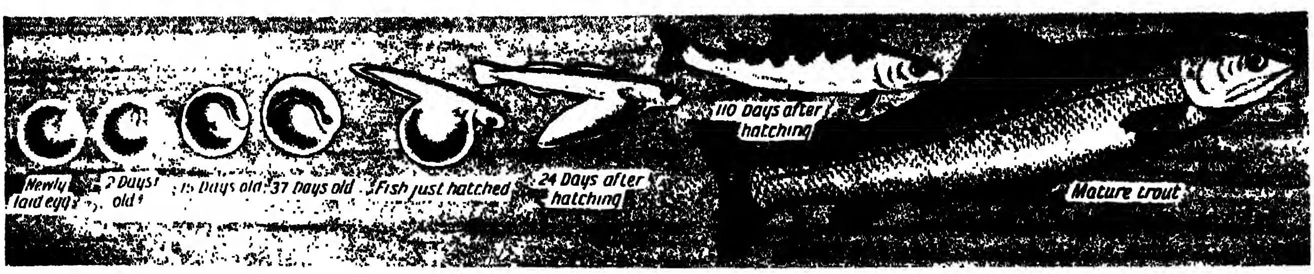
The Explanation of Science

These theories, however, have been given up by most men of science in recent years, and the opinion of many of them is that sleeping and waking are due to variations in the blood flow through the brain After a period of activity the nerve centres that control the blood vessels and have been sending the blood through the brain at adequate speed, become fatigued They then stimulate the blood vessels less energetically, and the blood flow is slowed down. This brings on the feeling of drowsiness.

After a period of rest the nerves controlling the blood vessels become active once more, the blood supply of the brain is increased, and the sleeper wakes.

People who are very tired and have been awake for a long period often fall asleep in most unfavourable surroundings. Horsemen, for example, have fallen asleep on their horses. Soldiers on the march have fallen asleep, and yet unconsciously gone on walking. And the story is told of the captain of a warship who actually fell asleep by the side of a cannon while this weapon was being fired again and again during the course of a battle.

THE LIFE-STORY OF THE COMMON TROUT



These pictures show the life-story of the trout. After the female fish has laid her eggs and they have been fertilised by the male covering them with milt from his soft roe, they develop, and successive stages are shown. After 40 days the little trout, known as an alevin, is hatched from the egg. At this stage it has no mouth, and draws nourishment from a sac on its underside, filled with yolk of the egg. As this yolk is absorbed the sac shrivels up The fish grows and at 12 months is known as a yearling. It is then three inches long, and is a perfect miniature of its parents. It goes on growing till it is mature and then it measures about three feet

MANY KINDS OF FAMILIAR RED SEAWEEDS

The coasts of Britain are really a lovely garden, for in the water grow almost countless varieties of seaweed They are of three main colours, green, olive and red, and are of every shape and form On this page are given twenty-two different species of the red seaweeds that are found growing round the British coasts For the sake of those who collect seaweeds and want to name their specimens we give the rather difficult names of those shown They are as follows: 1, Dasya coccinea; 2, Phyllophora rubens; 3, Delesseria alata; 4, Rhodymenia bifida; 5, Dumontia filiformis; 6, Corallina officinalis; 7, Delesseria sanguinea; 8, Iridaea edulis; 9, Laurencia pinnatifida; 10, Nitophyllum Hilliae; 11, Rhodymenia laciniata; 12, Nitophyllum laceratum; 13, Polysiphonia urceolata; 14, Rhodymenia ciliata; 15, Chylocladia articulata, 16, Gigartina mamillosa; 17, Polysiphonia violacea; 18, Furcellaria fastigiata; 19, Rhodomela subfusca; 20, Cystoclonium purpurascens; 21, Rytiphlaea thuyoides; 22, Phyllophora membranifolia

THE USEFUL REINDEER AND ITS WORK FOR MAN

It has been said that if it were not for the reindeer no human inhabitant could exist in Lapland. No other animal could compensate for its loss. It has been domesticated in Lapland and Finland and among many of the tribes of Northern Siberia from time immemorial. Some of the Siberian herds kept by the tribesmen are said to number forty or fifty thousand, but in Lapland it is quite exceptional to find a herd of more than five hundred.

The reindeer gives its masters flesh and milk for food, skin for clothing, sinews for thread and cordage and harness, and bones and horns for small articles of furniture and ornaments. In addition it is the beast of burden of those cold, snow-clad regions. The rich, cream-like milk is, during the summer months, made into small cheeses which form a useful food in winter.

While in Lapland and Norway the reindeer is used for pulling light, boat-like sledges over the snow, in Kamchatka it is saddled and ridden. Further, pack saddles are used on which goods to the weight of a hundred pounds are placed. The Tunguses often drive a train of from six to twelve reindeer in this way.

The antlers or horns are found in both sexes and originate on the upper part of the skull. These antlers vary very much in form, and it is difficult to find any two reindeer in which the horns are precisely similar. They are not even always symmetrical, the opposite sides differing in the same deer.

The reindeer is a rather heavily built animal, and the throat has a fringe of long, stiff hair. The ears are smaller than in any other deer, and both sides are covered with hair. The hair on the body is about an inch and a half long and rather wavy, and underneath this is a coat of woolly fur, so that the skin of the animal is of the greatest value to the Laplanders and others who live in the cold North. Wrapped in these the people can lie and sleep comfortably on the snow-clad or frozen ground.

Laplanders with two of their domesticated reindeer. It is the reindeer that makes human life possible in the far north of Europe and Asia, for this animal is not only the beast of burden, it also supplies food, clothing and other commodities

The reindeer of Finland is noted for its large size, standing about four feet at the shoulder, but the Swedish reindeer is smaller.

The reindeer can live nearly as far north as the limit of the land, and it is found all the year round in Spitzbergen. There are many wild herds in addition to the domesticated animals, but in Scandinavia these are becoming rare. The wild animals are larger than the domesticated variety.

In earlier ages, as we know from remains that have been found, the reindeer used to migrate in winter to Southern Europe. Even in Julius Caesar's time the Romans met with reindeer in Germany.

The caribou of North America is really another species of reindeer, and when, as has happened on several occasions, reindeer have been introduced into North America, the caribou have interbred with them, so near is the relationship. The caribou cannot be domesticated, and when a herd of caribou meet a herd of domestic reindeer they generally surround them and lead them off so that they are lost to domestication.

The offspring of caribou and reindeer are to all intents and purposes like wild caribou. The United States Government move their herds of reindeer south at certain seasons of the year to get them out of the track of the migrating caribou.

In winter the wild reindeer of Siberia and Scandinavia migrate south to the forests. It is said that they move slowly and majestically along when travelling to their winter quarters, the herds sometimes numbering thousands, and as they travel their broad antlers look like a wood of leafless trees moving along. Generally a large deer, said to be a female, leads the herd.

The food of the reindeer consists chiefly of lichen in spring and summer and seaweed in winter.

The reindeer once lived in the British Isles, for its remains are often found. In 1952 a small herd of reindeer from Norway was established in the North of Scotland with a view to re-establishing the animal in Great Britain

A 30-FOOT PYTHON'S BATTLE IN THE JUNGLE

The python of the Malayan jungle is a giant snake often thirty feet long. It has no poison glands, but kills its prey by coiling round the victim and crushing it. It is enormously muscular and breaks every bone in the body of the animal round which it coils. Then it swallows it head first. It can open its mouth very wide and it has powerful teeth. Here we see a python in battle with a tiger. The battle was drawn, neither creature being seriously hurt. This and the picture below are stills from a film taken in the jungle

Here is another remarkable still from a film taken in the Malayan jungle by an expedition sent to study wild life at close quarters. It shows a thirty-foot python struggling with a crocodile on the bank of a river. The python tried to crush the crocodile, and the amphibian lashed its tail to and fro. Eventually the fighters separated. Pythons are fond of lying in the water

THE HIGHEST MOUNTAIN IN THE WORLD

This photograph shows Mount Everest, the highest peak in the world The height of Mount Everest has been variously estimated at 29,028, 29 040 and 29 141 feet, but the official altitude is 29,002 feet above mean sea level The mountain does not look as high as many smaller mountains because instead of rising from a plain it is surrounded by other mountains almost as high as itself, these have the effect of dwarfing it There are more than forty peaks in the Himalaya Mountains over 24,000 feet high The name Himalaya means the abode of snow These mountains form a stupendous chain of folded rocks, but their strata are among the newer formations of the Earth's crust Mount Everest was climbed for the first time on May 29, 1953, by members of a British expedition (see page 317)

WHAT A WATERSPOUT REALLY IS

What is a waterspout? It used to be thought that it consisted of a great column of sea-water drawn up to join the clouds above, but it is now known that very little sea-water is drawn up by a waterspout; in fact, the water never rises for more than a few feet, and the bulk of the whirling column is made up of fresh water and vapour, a proof that it is condensed from the atmosphere and not drawn up from the sea's surface. Here we read something about the real nature of the waterspout.

We sometimes see pictures of waterspouts which represent a great column of sea-water rising high into the air and joining the clouds. But such a representation is contrary to the facts.

A waterspout is really a tornado at sea, and the part that is represented as a column of water rising from the sea is the whirling funnel-shaped cloud which always accompanies a tornado on land. We see this in the photographs on page 557. It is interesting to compare those photographs with the photograph which is given on this page. This picture shows the real appearance of the waterspout, and we can see that in this case the whirling columns do not actually touch the water.

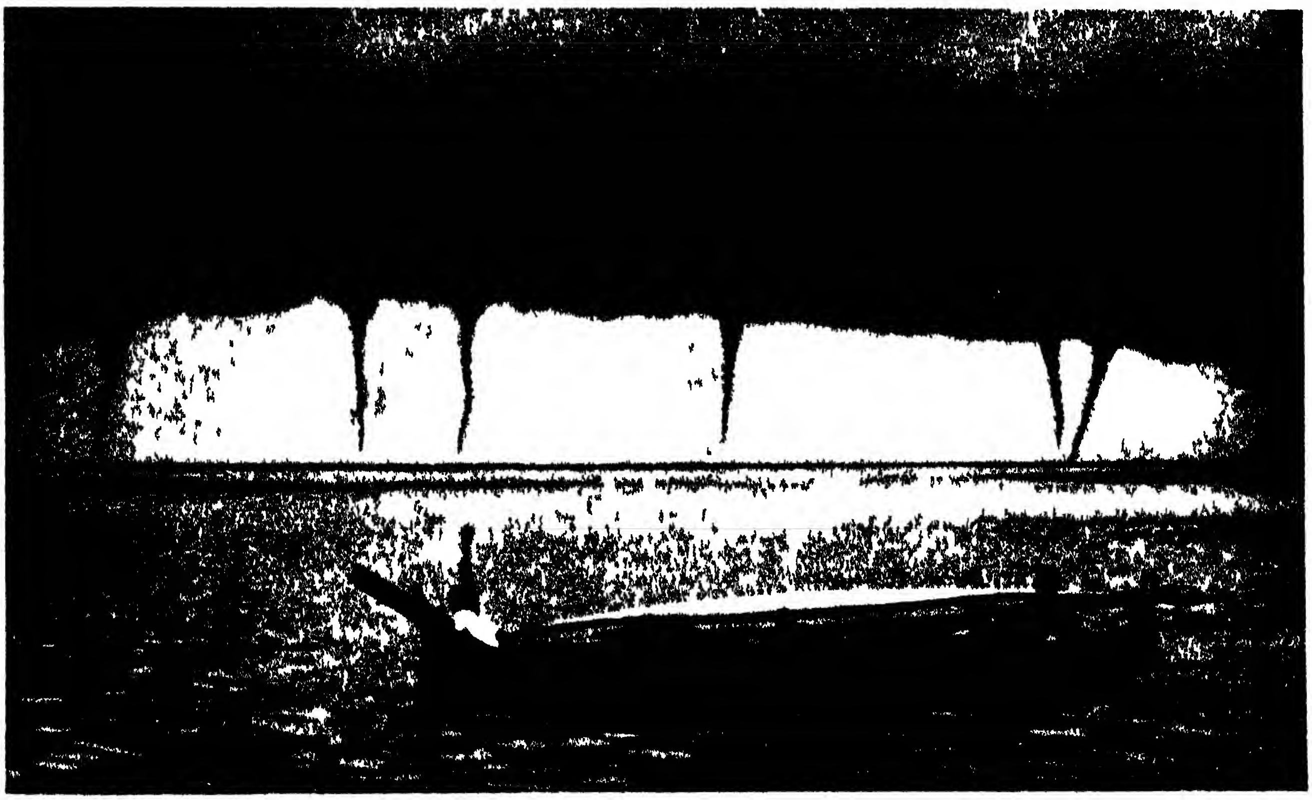
It is true, however, that when the waterspout actually touches the sea a certain amount of water does rise for a short distance. The air inside the whirling column is very rarefied, and so the pressure of the air on the sea all round drives a certain amount of water up into the column, but it never rises higher than a few feet, and is then whirled into spray, which may be carried higher. Of course, if the inside of the column were a perfect vacuum, then probably sea-water would be driven up inside it to a height of rather more than thirty feet.

The story of large quantities of water being carried up into the clouds is a pure myth, just a sailor's story. A waterspout has sometimes crossed the path of a ship, and it has always been found that the water inside the whirling column is fresh and not salt. This is a proof that the water of the waterspout is the product of condensation, and is not salt water carried up from the surface of the sea.

Whenever a tornado crosses a river, lake or pond it immediately becomes a waterspout, while waterspouts from the sea that run over the land at once show all the characteristics of tornadoes.

Waterspouts occur most frequently over warm and calm seas, but they are from time to time seen in the English Channel. They whirl round and travel about at an astonishing speed, but in the English seas at any rate are not long before they disappear.

The greater part of the water in a waterspout consists of cloud formed by the condensation of water vapour in the air, and the wonderful old stories about ships being carried up or wrecked in a moment by a waterspout are, if not inventions, great exaggerations. The tornadoes at sea taking the form of a waterspout never have the fierce force of the tornadoes that are experienced in America.



A remarkable photograph showing a series of six waterspouts seen at one time in the Sulu Archipelago near Borneo. A waterspout is really a tornado at sea, but it is less fierce in its action than the tornadoes experienced on land. The whirling columns are made up mostly of water vapour with a certain amount of condensed fresh water. They are not seen for long, for they soon disappear.

LUNAR HALOES AND MOCK SUNS

Circles of light are frequently seen round the bright full Moon and these are given various names according to their size. Sometimes the appearance is called a corona, at other times a halo. We read on page 385 how the rings are formed, sometimes by the light passing through drops of water in the atmosphere, as when a thin cloud comes between us and the Moon, and at other times by the tiny ice crystals in a cirro-stratus or alto-stratus cloud.

Sometimes a series of rings is seen surrounding the Moon at some distance from that body, and these rings are faintly coloured with the red on the outside and a whitish blue on the inside. The colour is of course due to the breaking up of the light.

The Breaking Up of Light

The process by which this takes place is known as diffraction, a word which means breaking in pieces. It is applied to the breaking up of white light into the coloured rays of which it is composed by passing through a narrow aperture or close to the edge of an opaque body. We get diffraction when we look at a bright light through a feather, and the mass of tiny rain-drops between us and the Moon acts as a grating in exactly the same way as the feather in our experiment does.

If we take a piece of plain glass and coat it with moisture, as when we hold it in the vapour coming from the spout of a kettle of boiling water, and then look at a bright light through the coated glass, we shall see a series of coloured rings, and this experiment shows us exactly how the lunar rainbows are caused. It also gives us an example of diffraction.

Much more interesting are the solar haloes with the parhelia or mock suns, which are frequently seen in the Arctic regions and occasionally in the British Isles. Parhelia is the plural of parhelion, and is from the Greek meaning near or beside the Sun. The phenomena of haloes and parhelia round the Sun are caused in the same way as the haloes round the Moon. The Sun's light in coming to us has to pass through a cloud made up of small ice crystals or needles, and these crystals break up the light.

The position of the Sun and the form of the cloud, the size of the ice crystals and so on all play their part, and the particular form of the appearance is dependent upon these various factors. Sometimes the circles and mock suns are very bright indeed.

A coloured circle round the Moon formed by the diffraction of the light as it passes through a cloud made up of drops of water

There are often several haloes and luminous arcs cutting one another with mathematical accuracy and studded with images of the Sun. Occasionally they are very fantastic in form and have the appearance of a complicated figure in geometry.

These strange phenomena have been noticed from the very earliest times. Aristotle and Pliny both refer to them, and in the old English chronicles there are many references to these mock suns. Up to comparatively modern times their appearance created quite a stir and people were alarmed because they thought such visions in the sky were a portent of some impending calamity.

Strange Forms of Mock Suns

Sometimes haloes and mock suns are seen during the daytime and in the evening of the same day haloes and mock moons. The conditions producing the two distinct phenomena are the same and have thus continued for hours.

During an appearance of the parhelia in France recorded by the astronomer Gassendi there were two concentric circles or haloes round the Sun, the larger one cutting the horizon and consequently being incomplete. These were coloured like the rainbow except that the red was inside and the violet outside. Above the larger circle, reaching in the direction of the zenith, was an arc or part of another halo, and with the zenith as a centre was a great white circle. Where the various circles touched or cut one another mock suns appeared, and still another was seen between the true Sun and the zenith or point overhead.

But we do not have to go to the Continent of Europe or to the Polar regions to find records of these mock suns. Several times in recent years the phenomenon has been seen in England. In 1920 there was a particularly dazzling example seen from the South Coast just before sunset. The mock suns were as bright as the actual Sun itself.

Sometimes these strange solar appearances take the form of perpendicular columns of light and they are often connected with mock suns. At other times spiral rays of a delicate pink rise from the horizon to the zenith with an appearance something like that of a blowpipe flame.

A striking appearance of solar haloes and mock suns seen in Norway. The circles showed the colours of the rainbow, with the red inside

THE REFLECTIONS OF CURVED MIRRORS

Mirrors are strange things. We speak of seeing ourselves in the looking-glass, and knowing what we look like; but, of course, the image that we see is not really a replica of ourselves, for everything is reversed. Our right eye becomes our left eye in the looking-glass. If our hair is parted on the left, in the looking-glass we have it parted on the right, and so on. When, however, instead of looking in a flat mirror, we look into one that is curved, we see all sorts of other strange things besides a simple reversal. There are curious distortions, and the reason for these we read in these pages

If we go into a room and look at the wall, whether it be covered with wallpaper or distemper, or has a curtain hanging over it, we see nothing but the wall or the curtain. If, passing along, we look out of the window, we see through the glass into the street or garden; but if, going still farther round the room we look into a mirror hanging on the wall, we see an image of our own face and body, and behind us we can see in the mirror a representation of the room in which we stand.

Why is it that when we look at the wall we see only the wall, when we look at the window we see through it into the street or garden beyond, and when we look at the mirror we see an image of ourselves and the room? Well, it is all a question of the behaviour of the rays of light.

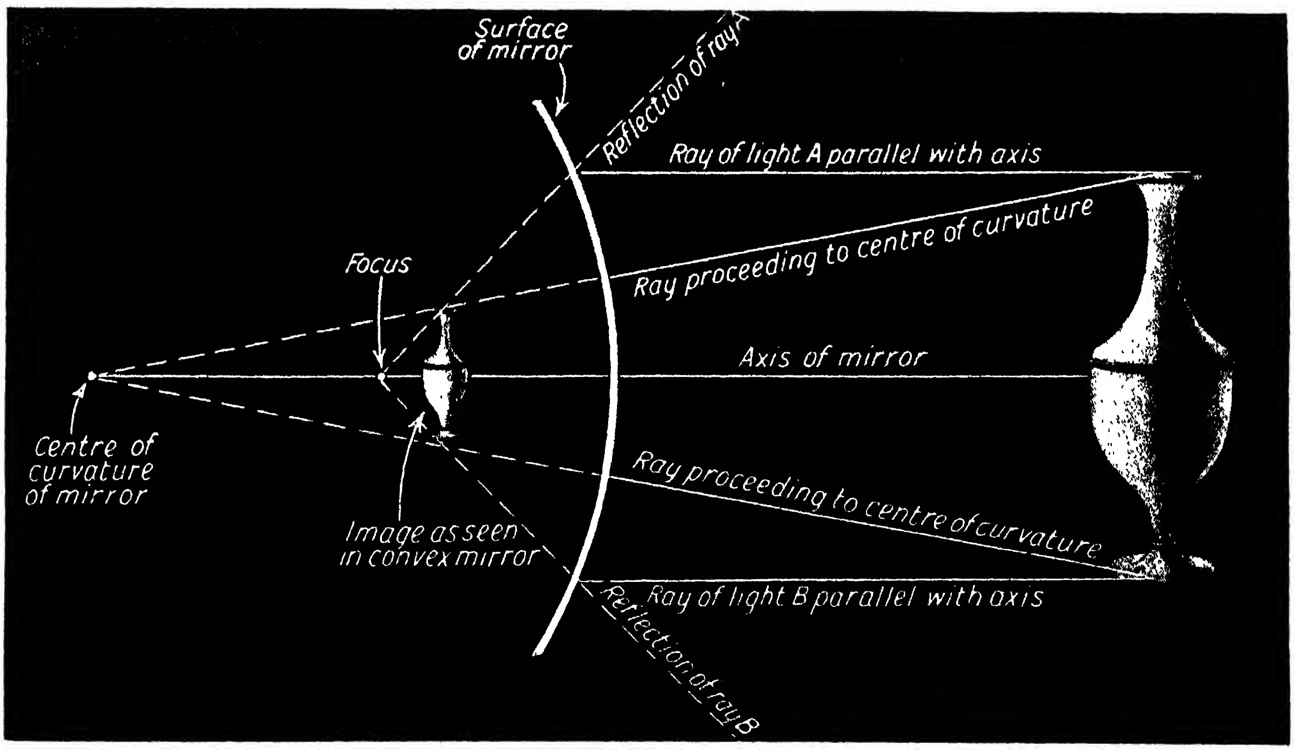
When we look at a wall or curtain, the rays of light passing from it to our eyes go through the pupil to the retina or curtain at the back of the eye where they stimulate the optic nerve, and send a message to the seeing part of our brain.

When we look out of the window the rays of light from objects beyond, that is in the street or garden, pass right through the glass to our eye, and we see not the glass but the objects on the far side.

When we look at the mirror we do not see through it, but the rays of light which pass from ourselves to the mirror are not absorbed as by the wall or curtain, nor do they pass through—as they do through the glass. They are reflected back by the metal which is on the back of the mirror, and so we see a reflection or image of ourselves and the other objects which are in front of the mirror.

The rays of light are reflected back very much in the same way as an india-rubber ball is sent back when we throw it at a wall. If we throw the ball at the wall in a line absolutely at right-angles to the surface of the wall it will come back to us in exactly the same direction, but if we throw it at an angle the ball bounces off at exactly the same angle in the other direction.

So it is with the light rays. The rays that strike the mirror at right



In this picture-diagram we see why the reflection of an image in a convex mirror is smaller than the image itself. The centre of curvature of the mirror is the centre of the sphere of which the curved mirror forms a part, and a line from this centre through the middle point of the mirror is called the axis of the mirror. A ray of light striking the mirror along this axis is reflected back in the same line. Other rays proceed from different parts of the object to the centre of curvature, and there are also rays of light which strike the mirror parallel with the axis. Two such are shown and are marked A and B. These, as they strike the mirror at parts other than the middle point, are reflected at an angle as shown, and these reflected rays if continued behind the mirror would meet at a point which is called the focus. The entire image of the object is seen between the points where the lines of the reflected rays cut the lines of those rays which proceed direct to the centre of curvature, hence its small size

angles to its surface come back along exactly the same line but the rays that strike it at an angle are reflected at the same angle in the opposite direction

It is just the same if the mirror be a sheet of polished metal such as the Ancients used Looking glasses to day have their back surfaces coated with a solution of silver varnished over to

These witch balls all of which reflect a miniature image of the objects in front of them with distortions at the side, consist of spheres of glass silvered on the inside The small figure seen in the centre of the balls is the photographer who took this picture The greater distortion of the photographer in some of the balls than in the large ball on the left is due to the fact that he was not so directly in front of the other balls The more an object is out of the centre of the mirror the more it is distorted

keep it from being scratched off but a few years ago the reflecting surface of a mirror was quicksilver

If a mirror has a flat surface it does not distort the image that it reflects back the image being the same size and shape as the object it represents but the position of the object is reversed that is the right eye of the person becomes the left eye of the face seen in the looking glass and objects that are on the left in the room appear on the right in the reflection

Men of science call this a lateral inversion Handwriting for example held up before the mirror appears backwards but if it is written backwards on a piece of paper and then held up before the mirror it is reversed so as to appear normal

Another interesting thing about the reflection in the looking glass is that an object placed before a flat mirror is seen as far behind the mirror as the object itself is in front of the glass

Sometimes when we go to an exhibition there is a Hall of Mirrors, where the looking glasses instead of being flat surfaces are curved some are concave, some convex some spherical and others wavy

When we look into these mirrors we do not see a proper image of ourselves reflected back but the figure is distorted in some way Sometimes the reflections are remarkably grotesque at other times they are inverted while at other times again the figure is enlarged or reduced in size All this is due to the way in which the rays of light that pass from ourselves to the reflecting surface of the mirror are sent back

An interesting illustration of what happens is found in the case of a spherical mirror such as a witch ball

If we look at a witch ball we find that the objects reflected are all much reduced in size while those at the sides are distorted by being bent round

The diagram on the previous page shows why the reflection in a spherical mirror is small in size It is the same with a convex mirror which, after all is only part of the surface of a sphere The centre of the sphere of which the mirror forms a part, is known as the centre of the mirror and the middle point of the reflecting surface is called the pole of the mirror, while the imaginary straight line joining the centre of the mirror to the pole is known as the principal axis

Now when a ray of light strikes the surface of the spherical mirror directly along its axis it is reflected back along the same line, but rays striking the mirror at other points of the surface behave differently

Some proceed in the direction of the centre of curvature while other rays are parallel with the axis of the mirror and these, as they strike the surface at various points are reflected back at angles If these reflected rays were continued behind the mirror they would meet at a point known as the focus

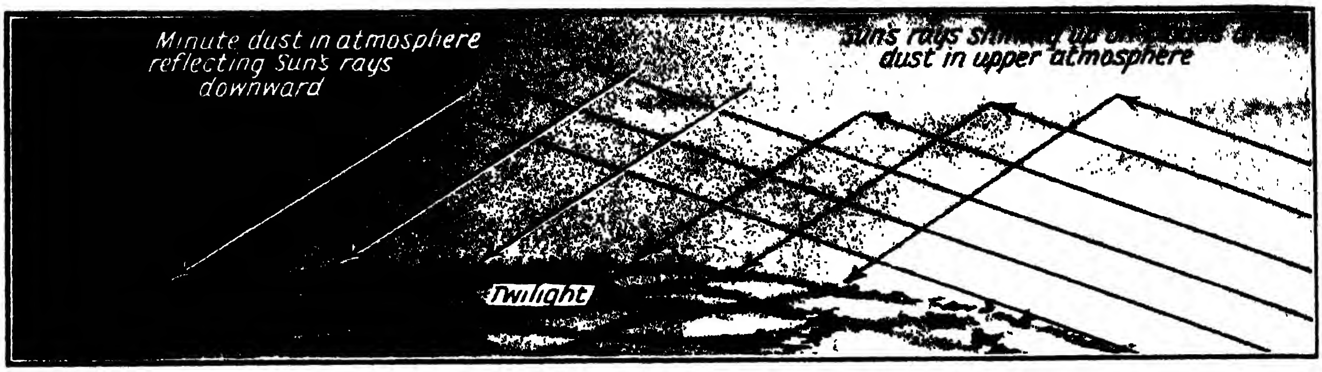
The image in the mirror is seen between the points where these rays cut one another, as shown in the picture diagram on page 621 This will explain why the image in the mirror is much smaller than the object in front

In more complicated forms of spherical mirror such as those shown in amusement halls at exhibitions with irregular curves turning in various directions and the reflection of the rays of light at all sorts of angles the most grotesque and curious effects are obtained—long noses one eye big and one small, big chins and no foreheads, and so on In fact, almost any effect can be obtained by curving the mirror in certain ways

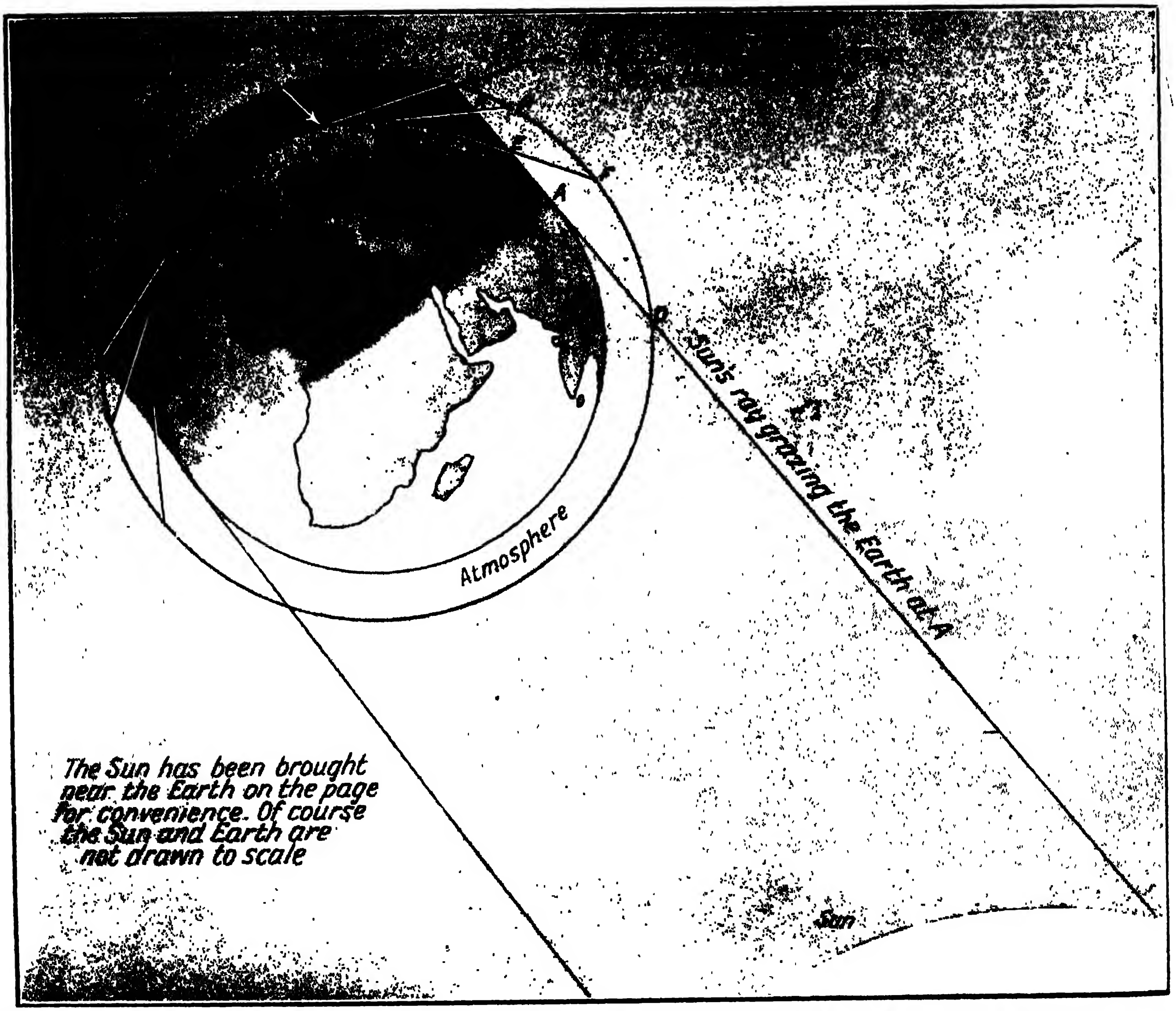
THE STRANGE REFLECTION IN A WITCH BALL

If we look into a mirror that has a flat surface we see a reflection of ourselves, but everything is reversed Our right eye becomes our left, and if we hold up handwriting or print in front of the mirror it will appear backwards When the mirror, instead of being a flat surface, is curved in any way, all sorts of queer distortions take place, and sometimes these are very grotesque In a concave mirror the object in front is seen upside down, but in a convex mirror such as the witch balls which are so popular, the image is the right way up but is very small In the flat mirror the image reflected is the same size as the object in front of the looking-glass In this picture we see the reflection in a witch ball which was placed on a pedestal in a garden. The man who photographed the ball with its reflection can be seen with his camera The reason for the reflected image appearing smaller than the original is explained in the diagram on page 621. The distortion at the sides is due to the different angles at which the rays of light are reflected by the ball

HOW THE TWILIGHT IS CAUSED ON THE EARTH



This picture shows how after the Sun has passed out of sight below the horizon, his rays still shine up and illuminate the clouds and dust particles in the atmosphere, which reflect them down at an angle and so give twilight to places from which the Sun has disappeared



This picture-diagram will help us to understand how the twilight is caused. When the Sun sinks below the horizon and cannot be seen its rays still illuminate the upper atmosphere with its clouds and dust particles, and from these the light is reflected down upon parts of the Earth where the Sun itself is invisible, giving a half light which we call twilight in the evening and dawn in the morning. In the diagram, where the sizes of Sun and Earth and the distance between them are not drawn to scale, the Sun is in the act of setting at the point A. D A C is a ray of light grazing the Earth at A and leaving the atmosphere at C. The point A is illuminated, by reflection of the part of the atmosphere C H F D. The point B where the Sun has already set receives no direct solar light, but it receives reflected twilight from that part of the atmosphere C E F which lies above the visible horizon B F. The point G receives twilight only from the small part of the atmosphere C K H, while at J the twilight has ceased altogether and darkness has fallen

THE REASON FOR TWILIGHT AND DAWN

The poets often refer to " twilight's last gleaming " and " dawn's early light," and it is well that we should know that both phenomena, twilight and dawn, are due to the same cause and that, as explained here, it is our atmosphere that is responsible for the gradual coming of day and night instead of there being a rapid transition from darkness to light and light to darkness

We are all glad to have the twilight which breaks for us gently the change from day to night, and from light to darkness. We get twilight in the evening after sunset, and we have it in the morning before sunrise, although then we usually call it dawn. But the half light before sunrise is due to exactly the same causes as the half light after sunset. What are those causes?

Well, it is due entirely to the fact of our having an atmosphere that we enjoy twilight instead of a sudden change from light to darkness when the Sun sinks below the horizon.

After the Sun has disappeared in the evening, its rays still illuminate the clouds and the myriads of dust particles in the upper atmosphere. By the atmosphere the light rays are refracted, that is they are broken or bent, and are then reflected by the clouds and dust particles to that part of the Earth from which the Sun has recently disappeared. The rays of light are also diffracted or broken up into bands of colour by the interference of the dust particles.

As the Sun continues to descend below the horizon, a less part of the atmosphere in question receives his direct light, and so less light is reflected to the surface of the Earth. At last all reflection ceases and night falls.

Before sunrise in the morning the same succession of events is experienced but in the reverse order.

The length of twilight varies with the season of the year and with the position of a place on the Earth's surface. Its duration is generally reckoned to last till the Sun's depression below the horizon amounts to 18 degrees, but it varies somewhat.

At the equator twilight lasts 1 hour 12 minutes, while at the North pole there is twilight continuously from January 29th till about the middle of March, when the Sun rises above the horizon and continues so uninterruptedly for six months.

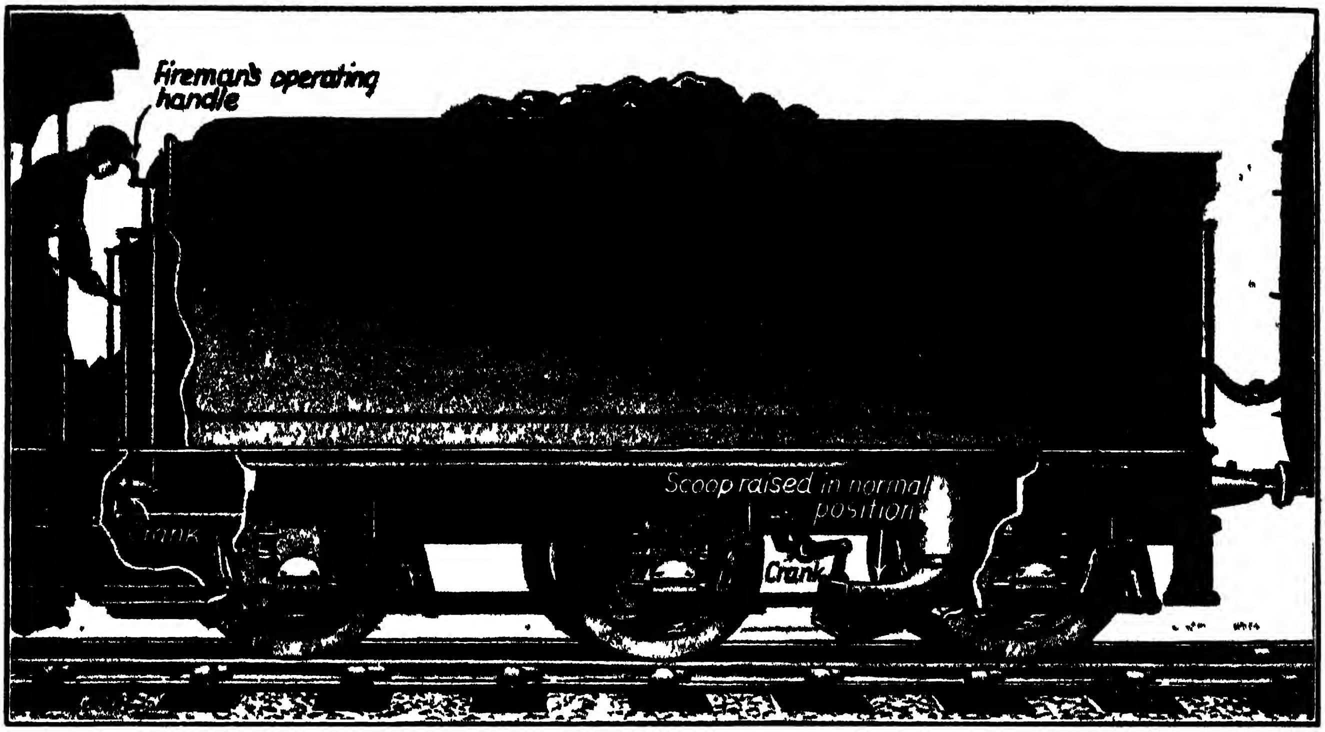
At intermediate points on the Earth's surface the duration of twilight may vary from 1 hour 12 minutes to several weeks. In the latitude of Greenwich there is no true night from May 22nd to July 21st, but constant twilight is experienced from sunset to sunrise. In this latitude it reaches its minimum three weeks before the Spring equinox and three weeks after the Autumnal equinox when twilight lasts 1 hour 50 minutes.

Of course, in cloudy weather we do not notice the twilight so much, as the clouds obscure the light.

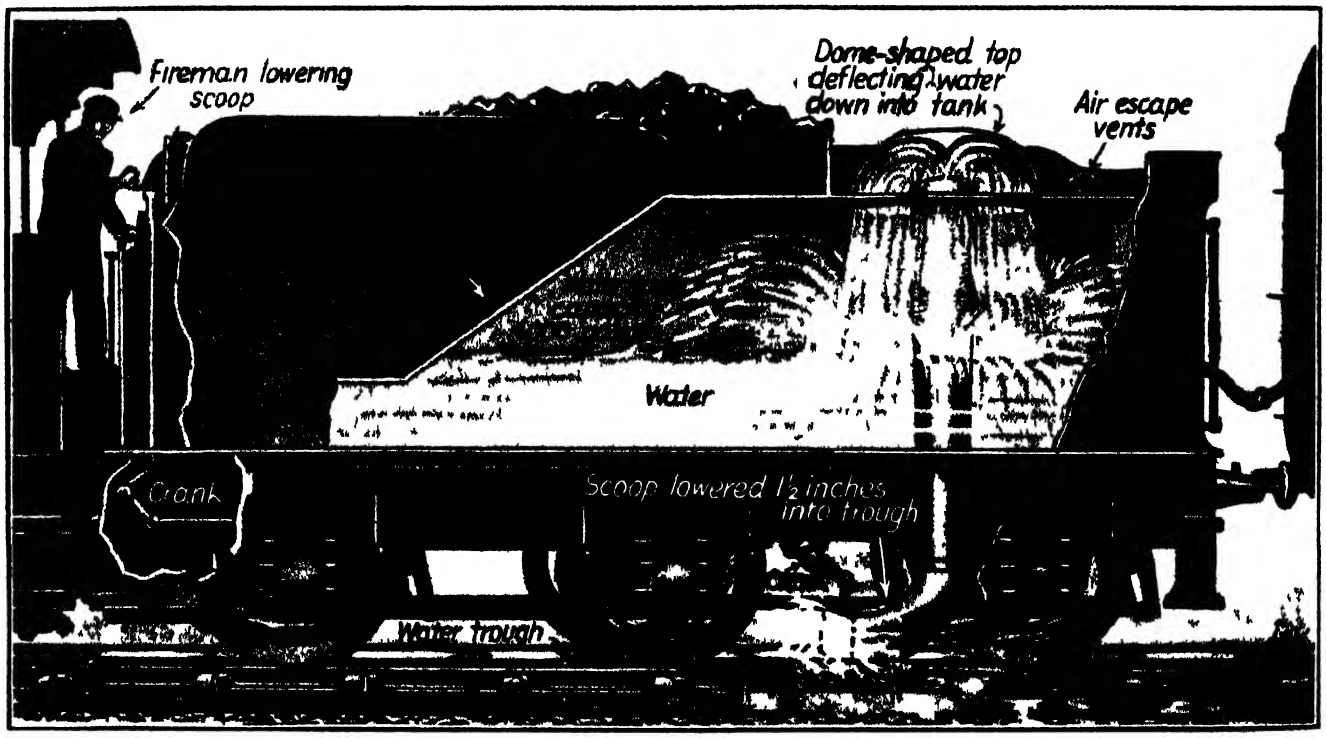
It is partly by means of the twilight that the height of the atmosphere has been estimated. It must reach to a height of at least 45 miles to account for the phenomenon, but of course with more modern methods of testing the atmosphere's height we know now that it extends to a much greater height.

The passage from light to darkness at sunset is much more rapid as we approach the equator than it is nearer the poles. In England, for example, the twilight lasts much longer than it does in Egypt, where this photograph was taken just after the Sun had sunk below the horizon.

A RUNNING ENGINE TAKES UP WATER



An express engine rushing through the country at fifty or sixty miles an hour can take up fresh supplies of water from a trough between the rails as shown in these pictures The water is taken up by a scoop which is let down by the fireman in the cab, who turns a handle and thereby works a series of cranks Here the scoop is shown raised above the track in its normal position



When the engine approaches the trough the scoop is lowered, and as it rushes through the water the liquid is forced up the scoop into a vertical pipe A dome-shaped cover deflects the water into the tank, and as the water enters the air escapes through a vent From 2,000 to 3,000 gallons are picked up in 15 or 20 seconds A water gauge in the cab records the amount in the tank The trough is 6 inches deep and 18 inches wide, and the rails on which the train runs are laid on a slight down gradient at each end towards the centre of the trough If the fireman should forget to raise the scoop the up gradient at the end will raise it clear The water level in the trough is maintained by a cistern and pump at the side, with a device like the ball valve in the domestic cistern. When the water level falls the float in the cistern also falls and permits water to flow into the trough. It is the inertia of the water, that is its tendency to remain where it is, that causes it to go up the scoop instead of being driven forward in the trough

ALL SORTS & CONDITIONS OF CLOUDS

The study of the clouds is an important element in the forecasting of the weather. There are five adjectives used to describe the degree of cloudiness of the sky. When no clouds are visible we say it is "cloudless"; when not more than three-tenths of the sky is covered with cloud we call it "clear"; when from three to seven-tenths of the sky is covered it is said to be "partly cloudy," and "cloudy" is used to describe a sky that is more than seven-tenths but not all covered with cloud. A sky completely covered is said to be "overcast." In these pages we read many interesting things about the clouds

THE formation of clouds is quite easy to understand. Moisture is evaporated from the sea and other sources by the Sun's heat, and enters the air as an invisible vapour.

The warmer the air is the more aqueous vapour it can contain, and when it holds the limit that it can contain at a given temperature the air is said to be saturated. Thereupon the least reduction of temperature will mean that a certain amount of the vapour will cease to continue in the gaseous condition and become condensed into tiny drops of water. If this condensation takes place near the ground we call it fog or mist, but if it takes place in the upper atmosphere we call it clouds.

It is a curious thing that, though the Ancients were great students of the heavens and named so many of the stars and constellations, they never seem to have given names to the different forms of clouds. It was not till the beginning of the nineteenth century that a French naturalist, Jean Lamarck, proposed that the clouds should be classified and given regular names.

A year or two later a London scientist, Luke Howard, proposed a system which with slight modifications is the one now in use. He pointed out that there were four main types of cloud, and to these he gave the Latin names of Cirrus, meaning "a lock of hair"; Cumulus, meaning "a heap"; Stratus, meaning "a layer"; and Nimbus, the Latin word for a storm cloud. The name in each case indicates quite clearly the form of the cloud.

There are, of course, all kinds of variations, and these have been given such names as cirro-stratus, strato-cumulus, and so on. This kind of name was multiplied a good deal during the nineteenth century, but in 1891 the International Meteorological Conference recommended a system by means of which clouds were divided under thirteen names.

The names of Howard's four main types were retained, and in addition the varieties were given the names: cirro-stratus, cirro-cumulus, strato-cumulus, cumulo-nimbus, alto-stratus, alto-cumulus, fracto-stratus, fracto-cumulus and fracto-nimbus. This classification of cloud forms is the one that is now recognised by all scientists.

The study of the clouds, their form, direction and speed, is known as Nephology, from the Greek word for cloud, "nephos," and an instrument by which the direction and speed of clouds is determined is a nephoscope.

We can see from this fine photograph taken in Essex why the cumulus clouds are commonly called the "woolpack," for they look like great masses of fleecy cotton-wool. They are formed by an ascending current of air whose vapour is rapidly condensed

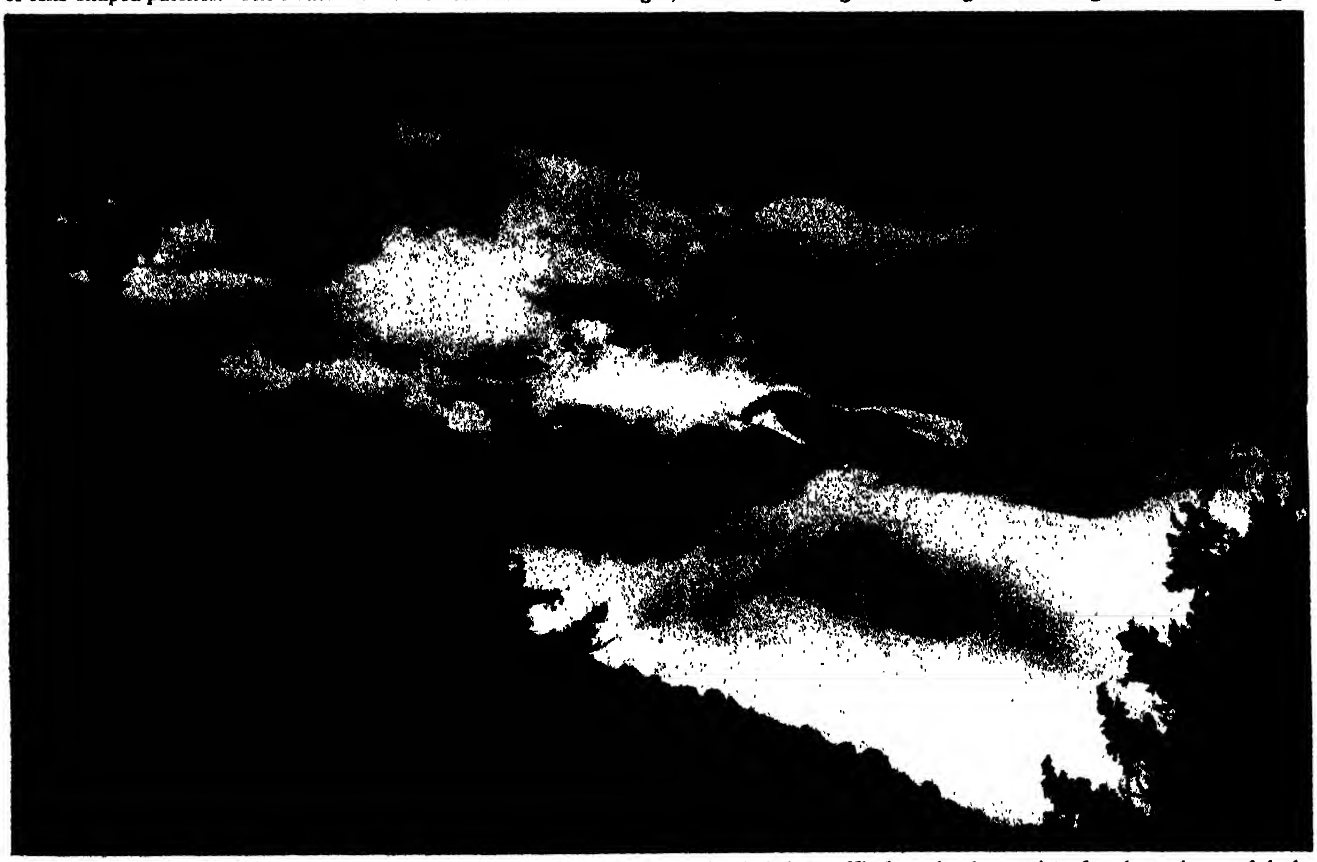
CUMULUS AND CIRRUS FORMS OF CLOUD

In this photograph we see Cumulus or "woolpack" clouds They are thick and the upper surface is generally dome-shaped with various bulges, while the base is horizontal When the Sun is opposite, shining on the clouds, the surfaces are more brilliant than the margins, but when the Sun is behind the clouds appear dark with bright edges The base of a cumulus cloud is generally about 4,500 feet high

Here we see Cirrus clouds, sometimes known as "mares' tails," which float 30,000 feet up Cirrus clouds are always of delicate appearance, white in colour, and feather-like in form. They vary, however, sometimes appearing like tufts of hair or thin filaments, and sometimes in bands They are often made up, not of drops of water, but of very small crystals of ice

STRATUS AND NIMBUS FORMS OF CLOUD

Here are Stratus clouds which appear in uniform layers and are always very low down, rarely more than 3,000 feet above the ground. They have been described as "lifted fog." They have no particular form. When stratus clouds break up they often appear as lenticular or lens-shaped patches. The stratus is considered as the cloud of night, for it owes its origin to evening mists and grows denser at night



This photograph shows Nimbus clouds with a layer of fog or stratus clouds below. Nimbus clouds consist of a dense layer of dark, shapeless cloud with ragged edges from which rain or snow usually falls. If the nimbus is broken up by a strong wind, or if a number of small detached clouds are drifting underneath, sailors call the appearance "scud"; scientists sometimes describe it as fracto-nimbus

HOW THE MOISTURE GETS INTO THE AIR

The bulk of the moisture which gets into the air is evaporated by the Sun from the sea. But it must be remembered that moisture does not rise only from the sea. There are many other sources of the aqueous vapour in the air, and these are shown in this picture-diagram, which is from a design by Mr Kenneth A Ray M A. Water rises from rivers, lakes, ponds, hot springs and geysers. A certain amount also gets into the air from volcanoes, for steam is thrown into the air during a volcanic eruption, especially if snow or water has accumulated in the crater during a period of rest. Then a great deal of moisture rises through the earth from underground water sources, and vegetation also gives off a great deal of moisture. All these sources shown in the picture contribute to the moisture in the air, which as it travels and strikes colder layers of air is condensed into small drops of water that form clouds ; or, if they are near the surface of the Earth, fogs. When the clouds strike still colder layers of air more water is condensed, the drops of moisture get too heavy to be suspended any longer, and fall as rain, or if the air is very cold the vapour is frozen into crystals which form snowflakes and fall as snow. So the endless round of evaporation and condensation goes on all over the world, though in some parts there is far more than in others

WHY THE SEA IS SALT

THE MANY DIFFERENT SUBSTANCES FOUND IN SEA-WATER

When we go to the seaside and bathe we know as soon as we get a mouthful of sea-water that the sea is salt. This is quite evident to the taste, and if we think at all a number of interesting questions must arise in our minds. Where did the sea get its salt ? How much salt is there in the sea, and why is river-water not salt ?

There is a folk-lore story which professes to explain the matter by telling how a ship on board of which there was a mill grinding out salt went down to the bottom of the ocean. All the people on board were drowned, and as there was nobody to stop the mill it has gone on ever since grinding out salt Of course, that is a picturesque story, but we must look elsewhere for the explanation of where the sea obtained its salt.

How Rivers Bring Salt

Probably the sea has always been salt. When the oceans were first condensed out of the atmosphere of gases and vapour that enveloped the planet there were no doubt in this atmosphere salt vapours, and these would be carried down by the condensing water into the primeval ocean.

But even supposing there had been no salt in the early atmosphere, and that the original ocean had been quite fresh, the water would have become salt by now. The sun pours down upon the surface of the ocean, turning the water into invisible vapour, which rises and later becomes condensed in the clouds, and then falls as rain to feed the streams and rivers. As the rivers pass over the land they dissolve a certain amount of the minerals of the Earth and carry this down with them to the sea. Then when the sun evaporates some of this water the mineral matter is left behind, dissolved in the water which remains, and so the ocean is ever getting salter.

At the present time the ocean contains on an average nearly 3½ per cent. of dissolved mineral matter. This means that in every hundred pounds of sea-water there are nearly 3½ pounds of salt.

But the salt is not all common salt, or sodium chloride, as chemists call it. That makes up a little more than three-quarters of the total mineral matter dissolved in the sea, and the remainder consists of small quantities of various other salts. An analysis of the mineral matter in sea-water shows the following proportions in every 100 parts by weight: sodium chloride, or common salt, 77·76 ; magnesium chloride, 10·88; magnesium sulphate or Epsom-salt, 4·74 ; calcium sulphate or gypsum, 3·60 ; potassium sulphate, 2·46 ; calcium carbonate or limestone, 0·34 ; and magnesium bromide, 0·22.

The popular idea that the water of rivers and lakes is fresh is quite incorrect. No such thing as pure liquid water is found anywhere in Nature ; rain-water is often nearly pure, but in falling from the clouds it dissolves various gases in the atmosphere and then when it flows through the earth or over the earth it is dissolving mineral matter all the time, the gases which it has taken up from the atmosphere assisting in the work of solution. River-water, therefore, is salt, but nothing like so salt as the sea, and so we cannot detect the saltness by taste. As a matter of fact, the water of the ocean contains nearly 200 times as much dissolved mineral matter as the water of the rivers.

A man is able to float easily in the Dead Sea of Palestine, where the density of the water is so great that it is impossible for a person to sink or drown

The very careful analyses of salt water which are made nowadays have shown that in addition to the substances already mentioned nearly every known element is found in solution in the sea, but most of them are in such very minute quantities that they can be detected only by the most delicate means

Watching the Crystals Form

We can see the salt in sea-water for ourselves if we carry out a simple experiment. Let us take a little sea-water and place it in a shallow vessel in a sheltered place, covering it with a sheet of paper, so that no dust may get in. After a time the water will evaporate We can then put a little more sea-water in, and let that also evaporate, and by this time we shall see that a number of minute crystals have been left behind in the bottom of the vessel. These crystals are the salts of the sea.

The experiment can be made even more interesting if, when the water has nearly evaporated, we examine a little of it through the microscope. When the water has nearly gone we stir it up and then put a drop or two on a thin glass slide under the microscope, and watch it. The water continues to go off as vapour, and as it does so we shall see the various salts forming into little bodies of definite shape, known as crystals. They seem to rush about, some of them uniting. Certain of the crystals will be oblong and pointed, and these are sulphate of lime or gypsum. Others consist of tiny squares, and these are the crystals of common salt. The different shapes of the crystals indicate the different kinds of salt which were in the drop of sea-water. We read about the wonder of crystals in another part of this book.

If while the crystals are on the slide under the microscope we breathe gently on it, we shall find that the moisture of our breath dissolves the crystals until at last they all disappear into a little drop of water formed from our breath

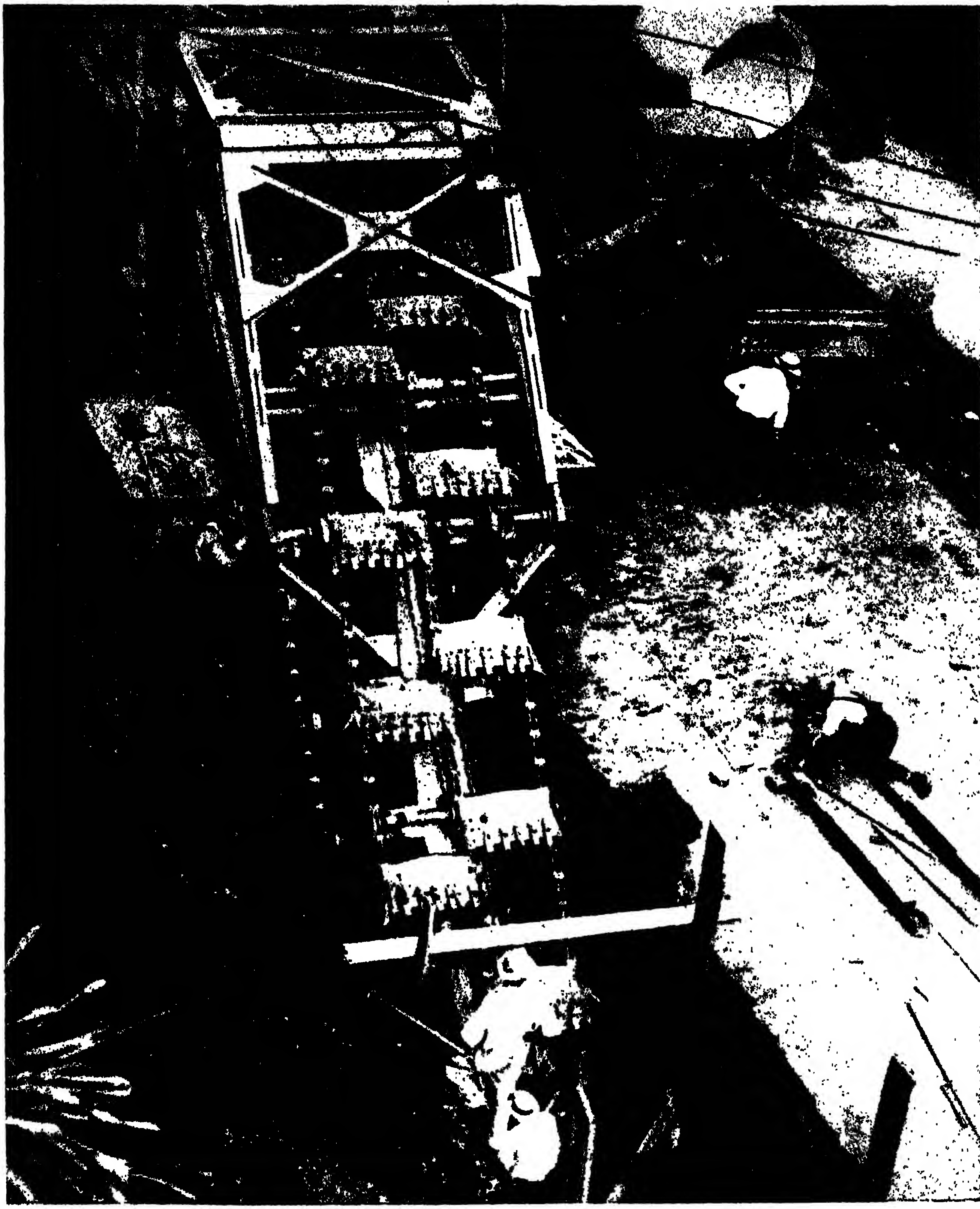
Salt Water and Fresh

The total quantity of salt in the ocean is enormous, and Dr. H. R. Mill tells us that it would suffice to form a solid crust 170 feet thick over the entire surface of the sea. This volume of mineral matter would equal in size about one-fifth of all the land that now shows above the sea.

Of course, the saltness of the sea makes sea-water denser or heavier than fresh water. A bottle filled with sea-water will weigh more than the same bottle filled with river-water. If we reckon the density of perfectly pure water as 1, then the average density of sea-water is 1·026, or in other words, if a certain quantity of distilled water weighs 1,000 ounces, the same quantity of sea-water will weigh 1,026 ounces.

But all the water of the sea is not equally salt. Generally the surface water is salter than that lying below, and among the causes which operate to make the sea less or more salt are the amount of evaporation, the rainfall, and the quantity of fresh water poured into the ocean from rivers In those seas which are situated in regions where there is a great rainfall, or where large rivers like the Amazon are continually pouring in hundreds of thousands of gallons of fresh water, or as in the Arctic and Antarctic regions, melting ice adds to the quantity of fresh water, the saltness is considerably less than in those parts of the world where there is little rainfall and where the hot sun causes great evaporation

THE BIGGEST TRENCH DIGGER IN THE WORLD



Machines to do the hard manual work of excavating have been marvellously developed in recent years. This form of rough labour is very expensive if carried out by hand in civilised countries, where wages are high. It is this fact that has led to so much attention being given by inventors to the production of excavating machinery. In this picture we have an example of the wonders that have been accomplished in this direction. The photograph shows the world's largest trench digger making a wide ditch for a giant pipe line. The digger does the work of a thousand men. There are two sets of steel teeth working on endless chains, and as these move round they grab large sections of earth and carry them up to the top, where they are loaded into lorries ready for carrying away

SOME GIANT DIGGING MACHINES

Of all forms of labour-saving machinery, that which should give the greatest satisfaction is machinery that replaces hard and uninteresting manual labour, such as digging and excavating. Steam shovels and other mechanical devices to perform work of this kind have been brought to perfection in recent years, and in these pages we read something about such machines

THE inventor of mechanical devices for excavating the earth has been amazingly successful. He has produced a variety of gigantic machines which can do the work of hundreds of men in a tenth of the time that would be occupied by manual labour, and these machines are adapted to every possible condition, material and situation.

Some mechanical excavators are in the form of great dredging machines with endless chains of buckets that bring up every hour hundreds of tons of material from the bottom of a canal or river and load it into barges or cast it on the bank at the side.

Big Shovels

Other machines are in the form of huge shovels which scoop up a hundred tons every time they are dug into a bank. And others again are used for digging trenches and ditches or removing material for the making of roadways. Some of these various types are shown in the striking photographs given on these pages.

There are excavators with revolving shovels, something like the front of a rotating snow-plough. As the circular shovel goes round it digs away even hard material at an astonishing rate and makes a way for itself as it digs ahead.

Some of the great power shovels dig forward into the bank, while others, worked from a tower, are dragged along the earth towards the tower, the bucket scooping up the earth as it moves and loading the material into wagons, which follow up the machine. These great excavators move forward on caterpillar tracks and are thus prevented from sinking into soft earth.

When one remembers that in the making of the Panama Canal about 240 million cubic yards of earth and rock, weighing something like 400 million tons, had to be dug out and removed to make the channel for the ships, one can understand that such a task would have been beyond human capacity had it not been for the invention of these gigantic excavating machines to do the arduous work.

In one day alone as many as 333 loaded freight trains left the Culebra Cut with over 100,000 tons of excavated rock. The whole of the excavation of the Panama Canal, one of the greatest engineering tasks that man has ever carried out successfully, was performed by mechanical means.

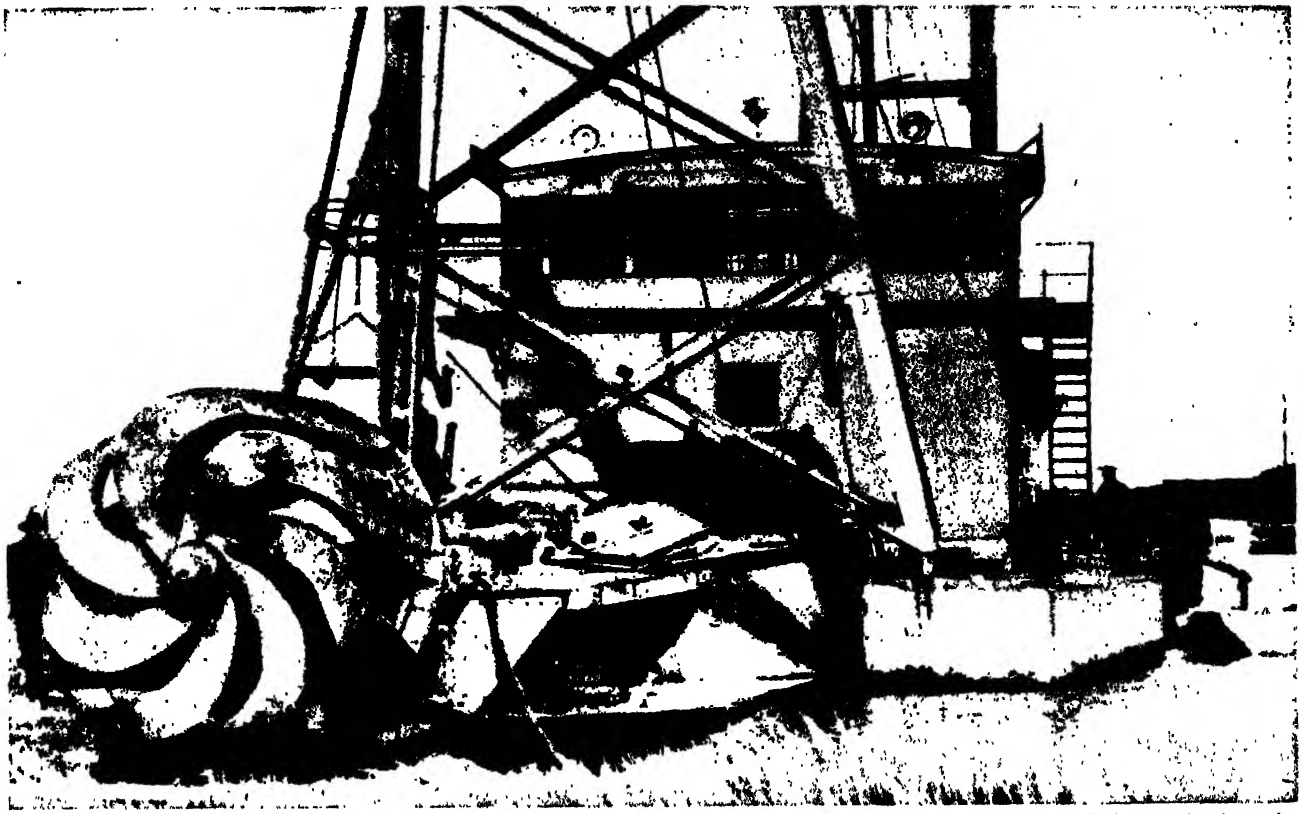
At Panama

There were at work 98 huge steam shovels, each weighing about a hundred tons, scooping up from five to ten tons of material at each stroke Each scoop was mounted at the end of a steel handle that could be swung in any direction. It had four great teeth of manganese steel on the upper edge, and when thrust against the material to be excavated scooped off a shovelful of perhaps ten tons, and made four such strokes a minute.

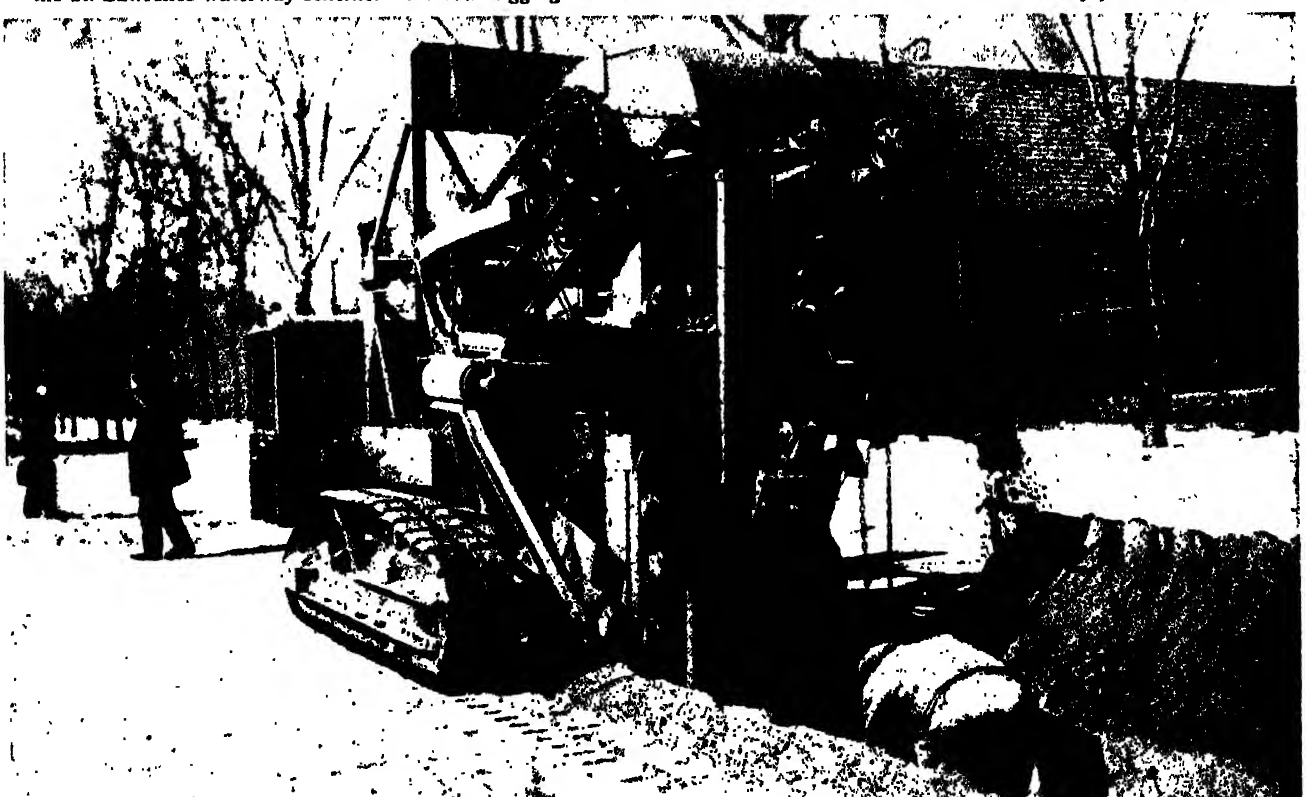
Of course, for the digging of really hard rock the rock was first blasted and the scoop then took away the debris.

A huge steam shovel at work excavating in the open pit of an iron mine in Minnesota. The mine is one of the greatest iron producers in America, but nothing like so much ore could be obtained from the mine were it not for this gigantic shovel, which digs out about twenty tons of material at one scoop. The shovelful can then be raised and turned in any direction for emptying.

GIANT EXCAVATORS SEEN AT WORK

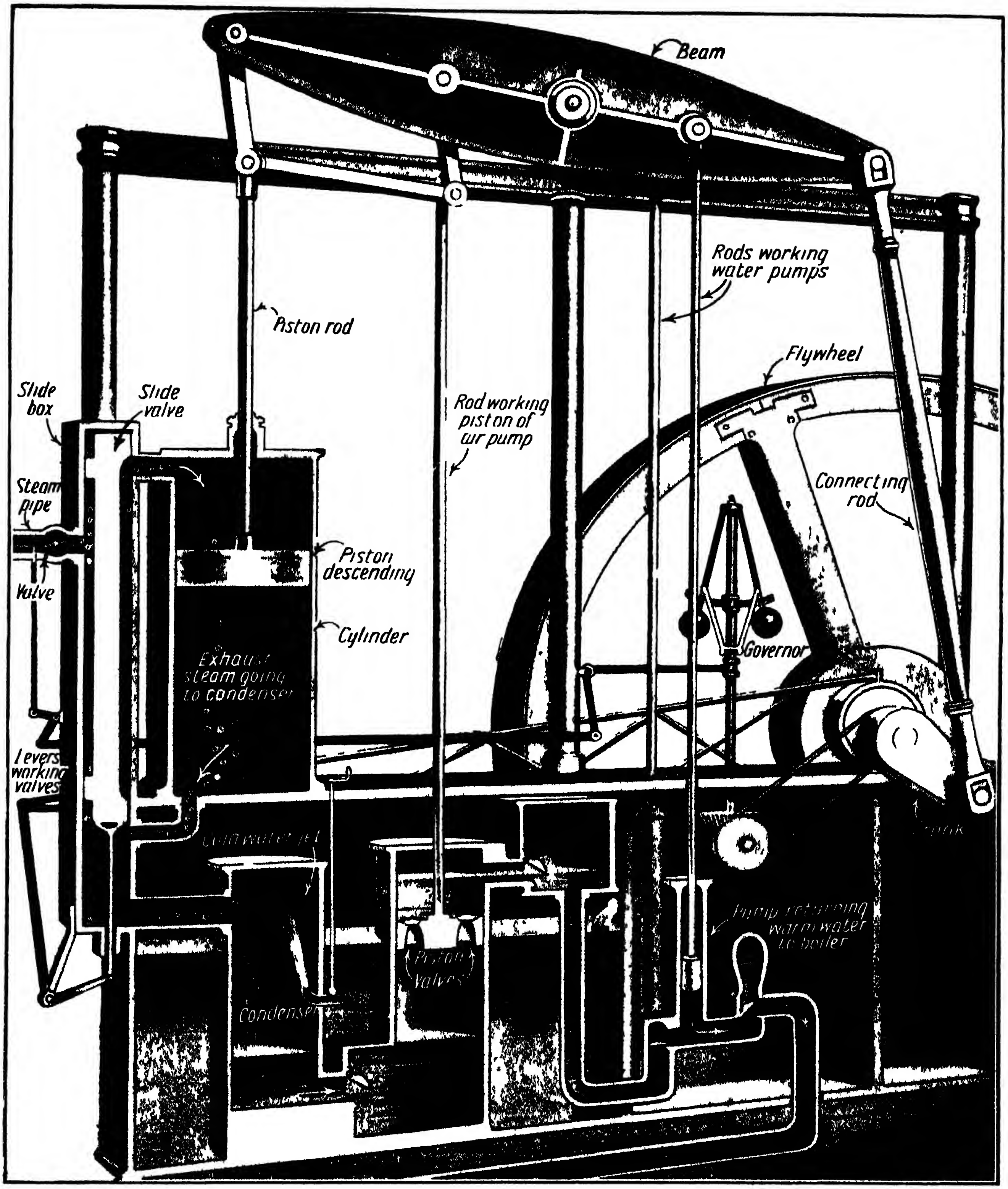


Here is a huge hydraulic dredge cutting a ship canal between two lakes on the St. Lawrence River in Canada. This machine bores its way along and excavates 200 cubic feet of earth a day. The canal it helped to dig is 300 feet wide and 27 feet deep, and forms part of the St. Lawrence waterway scheme. Without digging devices of this kind the canal would have taken many years to excavate



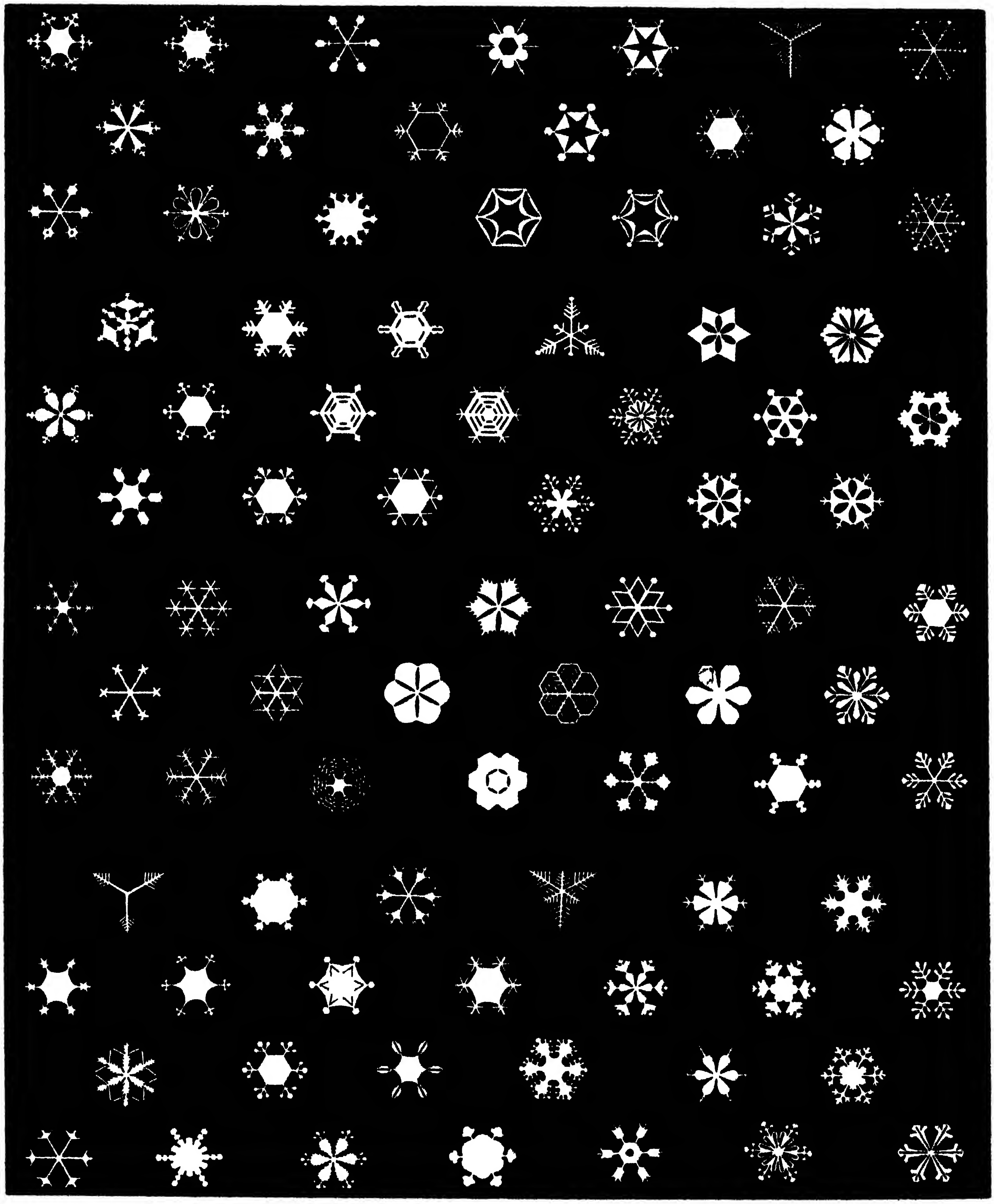
This giant digging machine is used for making trenches for the laying of cables and for road-making. It can make a trench over three hundred feet long and nearly three-and-a-half feet deep every hour. The machine moves backwards and forwards as required on tractors driven by the engine which operates the chain of bucket scoops. In this picture the machine is digging a trench in a street

HOW A BEAM STEAM ENGINE WORKS



Here is the type of steam engine developed by James Watt, and still used for pumping at many mines and waterworks The steam enters the cylinder from the boiler through the steam-pipe, and alternately raises and depresses the piston, the waste steam passing to the condenser, where it is condensed into liquid by a jet of cold water The piston-rod is connected with the beam which sets the flywheel in motion by means of a connecting-rod and crank. The flywheel regulates the speed of revolution, and thereby equalises the motion of the engine The engine thus moves at a uniform rate An endless belt moving round the axis of the flywheel transmits the motion of the engine to the machinery The beam by means of a rod works an air-pump which constantly empties the condenser and by means of other rods it works the water pumps, which pump cold water into the condenser and warm water from the condenser back into the boiler through a pipe An eccentric disc attached to the shaft of the flywheel moves rods which, by means of levers, work the valves of the slide-box A governor worked from the flywheel and moving by centrifugal force regulates by means of the valves the quantity of steam passing to the engine As the governor rotates faster the balls fly out farther, moving a sliding collar and operating valves

THE MANY BEAUTIFUL FORMS OF THE SNOWFLAKES



Snowflakes look very much alike as they fall, but if they are examined through a microscope they exhibit all kinds of beautiful forms, and their variety may almost be described as legion. The crystals consist of minute needles which combine to form symmetrical figures with six sides or six rays, but however they combine they always do so at angles of sixty degrees. There are literally thousands of forms which the snow crystals assume, and all those that are given on this page were taken from actual examples. This symmetrical formation in snow has been observed from ancient times. Aristotle refers to it. Of course when snow is falling heavily and the flakes press upon one another as they reach the ground the symmetrical formation is often spoilt. Their beauty is best seen during a light fall

THE DAWN OF THE BRITISH EMPIRE

The British Empire is the mightiest empire the world has ever seen, and yet its beginnings were anything but promising. Disaster after disaster overtook the early colonists, but in the end British grit triumphed. Here we read the story of the first English empire-builders, who included that chivalrous knight Sir Walter Raleigh

The British Empire is the greatest, the most powerful and the most successful empire that the world has ever known, yet its beginnings were anything but successful. Disaster seemed to dog the early founders of the Empire both at home and abroad, and although the seed was sown no one could have dreamed that it would grow into so great and flourishing a tree.

Columbus had discovered America, or rather the West Indies, in 1492 and a few years later Spaniards and Portuguese, with the blessing of the Pope, had taken possession of Central and South America. They exploited the natives, they rifled the continent of gold, and they did their best to exclude people of all other nations from doing any trade with the newly discovered countries.

Two Ideas

The English, however, were born traders. It was an age of expansion and adventure and not only the English but the French also determined that they were going to get some of the benefits of the new discoveries which had enlarged the world and widened its horizon.

The Spaniard's idea of colonisation was quite different from that of the Englishman or even of the Frenchman. He looked upon the new lands merely as sources from which wealth, and particularly gold, could be drawn. The natives were not to be conciliated, but enslaved. The Spaniard was to be master, and the native was to work wholly and solely for his benefit. No Spaniard wanted to settle down in America. He merely wanted to go there, get rich in as short a time as possible, and return to his native land, there to enjoy the fruits of his enterprise.

In England and also in France there was quite a different idea. Far-seeing men, among whom was the great Sir Walter Raleigh, realised that the mere extraction of gold from the mines of the new lands must sooner or later come to an end.

What was needed was the settlement of the new countries with colonists from the old land, who would build houses, cultivate farms, multiply, and build up prosperous communities which would produce raw materials for export to the Mother Country, and create a big demand for manufactured goods from their old land.

The first child of English parents to be born on the American continent was given the name of Virginia, after the colony named in honour of the virgin Queen Elizabeth

The French made a bad start more than twenty years before the English. In 1562 a body of French Huguenots, fleeing from persecution, sailed for Florida and settled down on that coast. But they soon quarrelled with the Indians, failed to sow crops for their own support, and, as Sir John Hawkins, the British mariner, reported, "would not take the pains so much as to fish in the river before their doors, but would have all things put in their mouths." The settlement soon broke up, but the next year a larger party of emigrants followed. They, however, seem to have been of the same type, and quarrelled among themselves.

French and Spanish

Then came the Spaniards, who had been warned of this Huguenot settlement by the French Court, which was hostile to heretics, and in a short time the settlement was attacked and utterly destroyed. Those Huguenots who were captured were hanged from trees, with a label attached to each stating that they were hanged "not as Frenchmen, but as Lutherans." When news of this outrage reached France a daring young French soldier organised an expedition and went out to Florida to exact vengeance. The Frenchmen seized the Spanish soldiers whom they found on the spot, suspended them on the same trees, and attached labels stating that they were hanged "not as Spaniards but as murderers."

Meanwhile what were the English doing?

In 1497, a Genoese pilot, John Cabot, who had settled in Bristol, obtained letters patent from King Henry VII to "seek out, discover, and find" all hitherto unknown lands. He sailed away with two ships

discovered Newfoundland, and, coming back with information about the rich fisheries in the waters round the island, received the handsome reward of £10 from the King's privy purse!

In the following year Cabot made a second voyage and is said to have sailed down the American coast from Baffin Bay to Delaware Bay. He certainly did not, so far as we can gather, explore the country, or occupy any part of it, but because he had discovered it England henceforth claimed all that part of the American mainland which Cabot had seen.

The English people, however, were not yet ready to begin empire-building, and although Martin Frobisher paid more than one visit to North America, it was not until 1578 that Sir Humphrey Gilbert and his cousin Sir Walter Raleigh obtained a patent from Queen Elizabeth giving them authority to plant a colony. Let us honour these two great Englishmen for their wisdom and foresight. They realised that if England was to thrive and expand she must have an empire overseas, so that her trade could ever increase. They were far greater men than any of the Spanish conquerors of South America, who had no power to see into the future and realise that colonisation and trade were the secrets of true empire-building, and not the mere acquisition of gold and silver.

Two Empire-Builders

Gilbert and Raleigh were not mere adventurers; they were scholars and men of taste and culture. They had studied geography and navigation and they could write their thoughts and views in clear English. Further they were great patriots, whose first aim was not wealth for themselves, but fame and greatness for their country

Of course, in those days the ambition of all seafaring European nations was to carry on a profitable trade with the Far East, and what the English wanted to do was to find a passage to the East Indies and China along the north coast of America It was a north-west route from England to the East that they sought, and that was the object of much of their adventurous voyaging

It is curious how religion was mixed up with trading in those days. Many of the advocates of increased trade, growing profits, and so on, did not fail to include in the great advantages which would come from colonisation, the conversion of the natives to Christianity. Some of them declared that this must be the chief motive of any colonising schemes. All countries lying north of Florida, one writer says, "God hath reserved to be reduced unto Christian civility by the English nation."

Colonies were also regarded as an excellent idea because to them could be sent from the Mother Country "vagabonds and such-like idle persons," who would then have to work to make a living.

Having obtained his patent, Sir Humphrey Gilbert created a joint stock company, with merchants and other well-to-do citizens as shareholders, and in 1583 a body of settlers in three ships anchored in the harbour of St. John's, the Queen's patent was read in the presence of all, and the territory within a radius of 800 miles was claimed in her name. The oath of allegiance was administered, and the arms of England erected.

This was the first English colony, and the very beginning of the British Empire overseas. Newfoundland is thus the oldest of all our Colonies.

There were 200 men, including some craftsmen, in the company of colonists, but soon quarrels broke out, many became sick, and Gilbert had to take his company on board again and set sail for England. It is a sad story, for on the return journey the ship in which he was sailing foundered at night, with all on board, and that was the end of the first British Empire-builder.

But though Gilbert was dead his work went on. In the following year Sir Walter Raleigh obtained a new patent and sent an exploring expedition across the Atlantic. Instead, however, of going to the bleak shores of Newfoundland, the party sailed farther south and landed on the island of Roanoke off what is now the North Carolina coast. They took possession of the island in the name of Queen Elizabeth, and then returned to England with a very glowing account of the genial climate, the rich soil, and the rumours they had heard from natives of stores of gold and pearls.

The letters C R O were found carved roughly on a tree as though they had been done in great haste

Queen Elizabeth was interested, and herself suggested the name of Virginia, as a memorial of her unmarried state. She appointed Raleigh the Governor and made him a knight. In 1585 a party of 107 settlers set sail in a fleet of seven ships under the command of Sir Richard Grenville, to form a colony in Virginia This was to be under the control of one of the party called Sir Ralph Lane, but he proved to be a very unsuitable man.

Early Troubles

The voyage was made safely, and the colonists landed on Roanoke Island They at once built a fort, the site of which can still be traced, and which is now maintained by the United States Government as a public park.

Grenville went back to England, leaving the colonists behind, but they, instead of cultivating the land and producing food and wealth with which they would be able to trade with the Old Country and buy the things they needed, began to seek for the precious metals and were soon quarrelling with the natives. Before very long they frightened off the Red men, on whom they were dependent for practically all their food.

However, Sir Francis Drake, cruising along the American coast with 23 ships, chanced to call at Roanoke Island, and was willing to give them supplies of food, although he had none too much for his own use. At this moment a terrific hurricane sprang up, and Lane, apparently alarmed, decided that the whole colony should return to England. Drake took them back, and they arrived in July of the same year.

The colony had left only a few days when a relief ship, which had been sent out by Raleigh with fresh provisions, arrived off Roanoke Island It was

surprised to find the island deserted. Two weeks later Sir Richard Grenville passed by, and he, too, was disappointed to find no one there. But he landed fifteen of his own men and gave them provisions to last for two years.

Meanwhile, Sir Walter Raleigh, in England, had not been idle. He had chosen another group of settlers, and these set sail from Portsmouth on May 8th, 1587. The party included seventeen women and nine children, and the colony was to be ruled by John White, an artist, and a dozen assistants, who were handed a charter for a city which they were to found in Virginia, to be called the "Citie of Ralegh."

Arriving at Roanoke, the party could discover no trace of the fifteen men who had been left there by Sir Richard Grenville, except the skeleton of one man, who, it was clear on examination, had been murdered. The colonists took possession of the fort, built rough cabins, and started to clear land on which to grow food.

Virginia Dare

On August 18th was born the first child of English parents to begin life on the American continent. She was the child of Ananias and Eleanor Dare, and was the granddaughter of Governor White. A week later she was christened, and was given the name of Virginia.

A few days later some of the company, including Governor White, set sail for England in order to obtain fresh supplies which they were to bring back in the spring, but when they reached home they found England preparing to meet the Great Armada of Philip of Spain, and so there was no time or opportunity to attend to the needs of the colonists. It was more than two years, therefore, before a relief expedition could set out for the little settlement on Roanoke Island.

After a voyage of five months the ships came in sight of the island, and everything seemed all right, for smoke was seen rising from the shore, an apparent sign of the presence of people there. Two boats were sent to the shore, while the ships fired their guns to attract the attention of the colonists. The party in the boats rowed towards the smoke and found that it was due to a forest fire, but nowhere on the shore was there any sign of their fellow-countrymen.

It was not till the next morning that they attempted to land, and then a sad thing happened, for one of the boats was capsized, and seven men were drowned. The other men landed, sounded a trumpet, and sang English songs, but there were no signs of life on the island.

The houses had disappeared, and search suggested that the island had been visited by savages, for Governor White tells us that "about the place were many of my things spoilt and broken, my books torn from the covers, the frames of some of my pictures and maps rotten and spoilt with rain, and my armour almost eaten through with rust. This could be no other but the deed of the savages our enemies, who had watched the departure of our men."

The fort was deserted, and there was no indication of what had happened. No bodies or skeletons were lying about, but it had been arranged that if the party had to desert the fort they would carve upon a tree the name of the place to which they were going, and if danger had threatened them they would add a cross.

The letters CRO were found carved roughly on a tree as though they had been done in great haste, but there was no cross under them. The CRO was supposed to refer to another island farther south called Croatan, which was the birthplace of a friendly native named Manteo, who had lived with the colony on Roanoke Island and had been baptised.

The End of the First Settlement

Governor White, referring to the damage he found on Roanoke Island, says, "Although it had grieved me to see such spoil of my goods, yet I greatly joyed that I had found a certain token of their safe-being at Croatan, which is the place where Manteo was born, and where the savages are our friends."

For some reason which we do not know White does not seem to have sailed to Croatan to see if the colonists were safely settled there. He returned to England, and when next Croatan Island was visited by English ships it was found to be deserted. There were neither English nor natives on the island.

That is the end of the first English settlement in America so far as the records tell. We know nothing whatever about what happened to the colonists, including little Virginia Dare.

In the next dozen years or so Sir Walter Raleigh is said to have sent out at least six expeditions to search for the missing English settlers, but no definite news could be gathered. The searchers, however, picked up rumours of white people living in what is now North Carolina, and when Jamestown was settled by Englishmen in 1607 Captain John Smith, who took the party there, heard that there were earlier settlers living somewhere inland.

The Pilgrim Fathers landing on Plymouth Rock. From the painting by Lucy

Old Traditions

It was said that they had gone into the country with native Croatans led by a Croatan chief; that some of them had been killed and a few, including a little maid, had escaped, that the natives had learnt from the white men to till the soil and build houses, smelt copper and make weapons; and that in the tribe there were some members who had blue eyes, and men who wore beards, which Indians never wore.

A century later Croatan traditions declared that the Croatan people were descended from Englishmen, and it was said that in their language were many English words. When the War of Independence came the Croatans joined the English side, and proudly claimed that their laws and religion had come from their English ancestors. There are also legends of a little white maid who grew up into a beautiful girl and was changed into a white roe.

It is said that even to-day the Croatans have preserved certain English words in their speech, and that a number of their family names are the names of men and women who formed a part of the lost colony.

We shall probably never know the true facts, but it is quite likely that

some members at any rate of the English colony on Roanoke Island travelled either willingly or as prisoners with the Croatan tribesmen inland and that little Virginia Dare was one of the party It was a romantic though sad beginning to the great British Empire which was to thrive so gloriously in later years

After James I came to the throne other expeditions went to Virginia and a colony was started at Jamestown named after the King It grew for a time and then trouble with the Indians occurred and 1 500 settlers were massacred It was a long time before the colony recovered from this disaster and began to grow steadily in wealth and population

All these settlers had gone from England with one of two purposes in their minds either adventure or gain But in 1620 a band of settlers sailed from Plymouth for America with an entirely new idea They were Puritans who were suffering persecution for their faith and they decided to go to a new land and settle down there making a permanent home for themselves where they could worship in peace free from persecution They are known in history as the Pilgrim Fathers and the ship in which they sailed was called the Mayflower

They landed on the coast of what is now the State of Massachusetts and we can still see the stone on which they first stepped ashore Like patriotic Englishmen they called the country New England and founded a town which they named after the English town from which they had sailed Plymouth

That was the real beginning of the British Empire as we understand it The party of Pilgrim Fathers, numbering a hundred included men women and children and they made up their minds to establish a real home beyond the seas and build up a community relying not on gold but on industry How well they succeeded we know by the condition of the United States to-day, with its 137 million inhabitants It is strange, however, to think that those people who had fled from England to avoid persecution should themselves have become persecutors in their new country

As the years went by Englishmen and Scotsmen went out to all parts of the world settling down and building up thriving communities, and bringing trade and wealth to the Mother Country

The Pilgrim Fathers holding their first meeting in America on Sunday, January 21st, 1621 From the painting by George Schwartze

Poor Raleigh's fate was even more tragic than that of his kinsman Sir Humphrey Gilbert He had spent £40 000 of his own money in trying to colonise Virginia, he had given England and Ireland the potato and tobacco and all the reward he got from his ungrateful Queen was that she put him in the Tower of London because he wanted to marry the lady of his choice, who was one of her maids of honour

After four years Raleigh was released, made various other expeditions, and then when James I came to the throne he was accused of being mixed up in a plot There seems to be no evidence whatever against him, but after an unfair trial at Winchester, in which he made a magnificent defence he was condemned to death On the very scaffold a reprieve arrived, commuting the death sentence to perpetual imprisonment

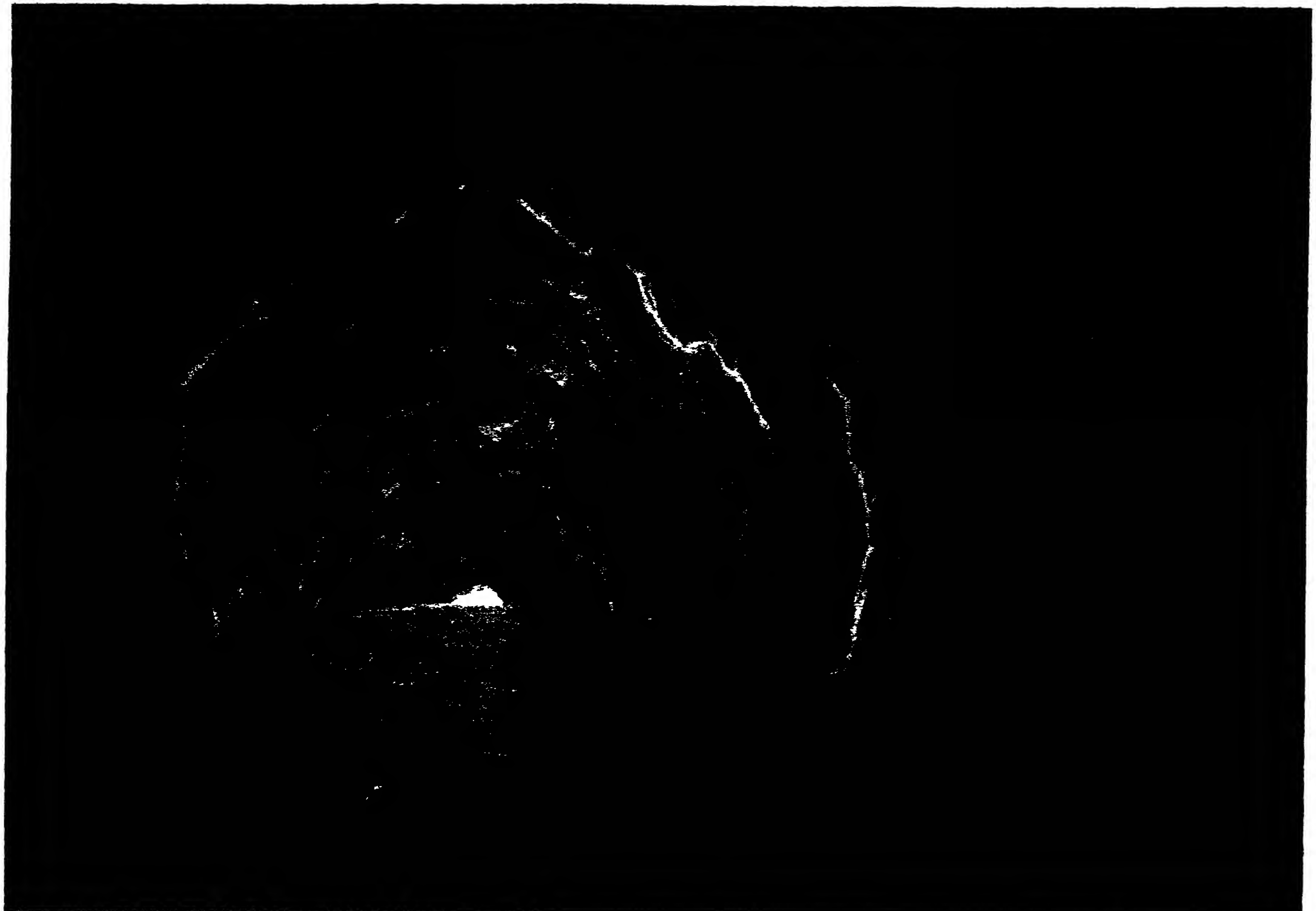
Raleigh remained in the Tower a prisoner for thirteen years during which time he wrote a number of books that are now classics the chief being a history of the world of which only the first volume was published It was suppressed as being "too saucy in censuring the acts of kings"

In 1616 Raleigh was released from the Tower in order that he might lead an expedition to the Orinoco River in search of a gold mine It was an unfortunate expedition and was dogged with disaster Storms desertion and disease all occurred, and Raleigh himself was laid low with fever While he was ill some of his ships sailed off on an expedition and burnt a Spanish town, and Raleigh's son was killed

The unfortunate Sir Walter had to return to England with the news that the gold mine had not been found, and this so angered the meanest king that has ever sat on the English throne that he ordered Raleigh's arrest and had him beheaded on the old sentence

It was a dastardly and despicable deed James would be branded as a coward for this one act alone

Sir Walter Raleigh, on the other hand, will ever live in the hearts of Englishmen as a great patriot, a cultured gentleman, and the real founder of the British Empire.



THE BEAUTY OF THE BLUE GROTTO EXPLAINED BY THE NATURAL LAWS OF LIGHT

The most celebrated feature of the beautiful isle of Capri, at the entrance to the Bay of Naples, is the Blue Grotto pictured here. When the sun is shining, the interior of this cavern, which stretches some 40 yards back from an entrance tunnel only 3 feet high, is flooded with an unearthly light shading through cobalt and sapphire to aquamarine and even emerald. The explanation is that sunlight entering the clear water outside the cave is refracted by the water as by a prism. The rays at the "blue end" of the spectrum, having the shortest wavelength, are the most sharply bent and are reflected upwards through the surface of the water within the grotto ; the longer red, orange, and yellow rays are insufficiently bent to be reflected back to the surface within 40 yards and are therefore "lost" in the water

WONDERS OF THE SKY

WE ALL TRAVEL MILLIONS OF MILES

Have you ever been abroad or do you travel about much in your own country? Perhaps not. You may rarely leave your own town, yet you are a great traveller. In the course of a year you journey hundreds of millions of miles. Perhaps this perplexes you, but the mystery is explained below

When you get out among the fields in the country or on the hills, how very quiet and still everything seems, especially in the evening. Yet you and the field and the trees are rushing through space at hundreds of miles an hour.

Think of this for a moment. The Earth turns round on its axis once in every 24 hours, and as it is about 25,000 miles round at the Equator, anybody standing on the Equator is rushing round at over a thousand miles an hour. Then the Earth is rushing round the Sun in its orbit at 18½ miles a second, which is equal to over 66,000 miles an hour, and further, the Sun with the Earth and the rest of his family of planets is tearing through space in the direction of the star Vega at about 40,000 miles an hour.

A boy lying asleep in bed is not really still. He is travelling through space at a thousand times the speed of an express train. If he were to be ill in bed for three months he would travel about 145 million miles round the Sun in that time.

A man was once forced by illness to keep to his bed for fourteen years, and during that time he had to lie on his back. He then, fortunately, recovered, but during those fourteen years he had been a great traveller, for he had covered a distance of over eight thousand million miles.

A curious thing was that he did not know he had been travelling, and perhaps the boys and girls who are fourteen years old and are reading these lines do not know that they too have travelled a similar distance since they were born.

M. Camille Flammarion, the great French astronomer, referring to this fact, says: "We travel on and on perpetually, carried along through Space on the most perfect of motor vehicles, propelled by a force stronger than steam, more irresistible than electricity. This motor car that breaks all records is the Earth, which races through infinity at the rate of more than a million and a half miles a day, or over eighteen miles a second, describing a vast curve round the Sun which it takes a year or 365 days to accomplish. Its speed is thus nearly 1,100 times more than that of an express train. As such a train goes 1,100 times faster than a tortoise, it would be like setting a tortoise to run after an express train if we could send a locomotive in pursuit of the Earth through Space."

Here is a boy asleep in bed. How still he seems. Yet he is travelling more than a thousand times faster than any express train could go. Even the 3,000 miles-an-hour speed of supersonic rockets is a snail's pace compared with this boy's, for he is travelling more than a million and a half miles a day with the earth in its journey round the Sun

MAKING A GREAT MAP OF THE HEAVENS

Maps of the heavens are made as well as maps of the Earth but these are even more difficult to prepare than terrestrial maps Astronomers all over the world are at the present time engaged in making a great star map of the entire heavens, and here we read something about their stupendous task

When we remember that according to some astronomers there are as many as 2 000 million stars in the heavens we can understand what a very difficult matter it is to make a map of the sky. In the old days before the invention of the telescope when men were dependent upon their unaided eyesight and only about 3 000 stars could be seen from the Northern Hemisphere it was not so difficult to make a map of the [illegible]

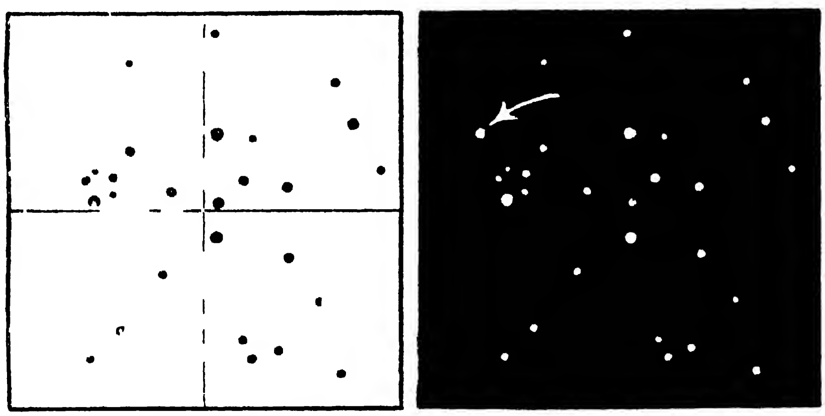
A Daring Thing to Do

One of the first to attempt such a map was Hipparchus an astronomer who lived at Rhodes more than a century before Jesus was born. It was a daring thing to do and Pliny the Roman historian writes of the event: "Hipparchus detected a new star and other new stars born in his own age and accordingly he ventured to do a thing which even in a god would be presumptuous—to enumerate the stars for posterity, devising instruments by which he could note the position and magnitude of each star so that it could be easily discerned not only whether they died or were born but whether any of them moved, the heavens being thus left as an inheritance to all if anyone should be found competent to receive it."

The invention of the telescope however made a great change and brought within human sight hundreds of thousands of stars which had not been seen before. The task of mapping the heavens now seemed too great and little was done in the matter but in 1675 a great English astronomer John Flamsteed who became the first Astronomer Royal pointed out that there were no accurate maps or catalogues of stars by which seamen could find the longitude at sea. Charles the Second on hearing this decided that the omission must be set right at once and so Greenwich Observatory was built and Flamsteed was put in charge so that the work long neglected might be done. He made the first modern star map and did splendid work which was improved and added to by his successors.

In these early star maps however only the brighter stars could be located and their positions measured. It was a tedious business but the invention of photography proved an almost untold blessing to astronomers. By using long exposures they were able to get accurate maps of parts of the heavens which included not only the bright stars but many that were too faint to be seen by the human eye even through a large telescope.

But while maps of parts of the heavens are very useful in their way and enable a good deal of information to be gleaned it was felt that a complete map of the heavens was needed. How could this be made? After a lot of discussion and negotiation it was arranged in 1887 that a number of the leading observatories in different parts of the world should divide up the work and each take photographs over a course of years of particular parts of the heavens. The photographs are to be uniform in character so that when the total number arranged for has been finished they can be pieced together to form a complete chart of the heavens.



These pictures show how the planet Neptune was found. After the discovery of Uranus in 1781 astronomers found that that planet's orbit was affected by some unknown body, and they indicated where this body ought to be. Search was then made, and, sure enough, on September 23rd, 1846, the planet Neptune was seen. When the existing star map on the left was compared with the section of the heavens it represented, a new shining point was seen, as indicated by the arrow in the right-hand picture, where in the chart nothing existed. This proved to be Neptune.

The great work was still going on in 1952 because new and more powerful telescopes bring more stars into view. Greenwich and Oxford observatories which took their part in making the big map have finished their tasks.

When the map is completed there will be no fewer than 30 000 star charts which if placed one above the other, would make a pile 30 feet high and would weigh two tons. It has been much more difficult to get the southern heavens mapped than the northern for there are fewer observatories suitably placed in the Southern Hemisphere but the work is going on and already about twenty million stars have had their photographs taken. Altogether eighteen observatories have undertaken the work.

But the work is not done when the photographs are taken. The positions of the stars have to be measured and recorded in a catalogue. Photographing the heavens for a purpose of this kind is a very different thing from taking photographs of people or places on the Earth.

It is important that the relative brightnesses of the different stars should be recorded on the photographic plate. But this is difficult as the late Professor H. H. Turner of Oxford who had a great deal to do with the making of the English star map explained.

Difficulties of Photography

"How are we to measure the brightness of stars photographically?" he asks. "In approaching any measurement of differences we must first satisfy ourselves that we can recognise equality. Let us define as of equal photographic magnitude two stars which impress the same plate equally in the same time and we need go no farther to encounter trouble. Suppose we pick out two stars by this rule. Will they remain equal if we substitute a different plate? The answer is in the negative for if one of the stars be a red star and the first plate be isochromatic we shall find the image of the red star much fainter on substituting an ordinary plate."

This question of the colour of the stars is not however the only difficulty for Professor Turner goes on to point out that two stars showing similar photographic images on the same plate may be made to give dissimilar images by slightly turning the telescope so that the images fall on different points of the plate or by refocusing the telescope when resuming observation the next night.

The apparent photographic magnitude may thus depend upon the

distance of the star from the centre of the plate and upon the particular focus selected for that plate. To decide, therefore, the magnitudes of the stars which are photographed is very difficult indeed.

Counting the Stars

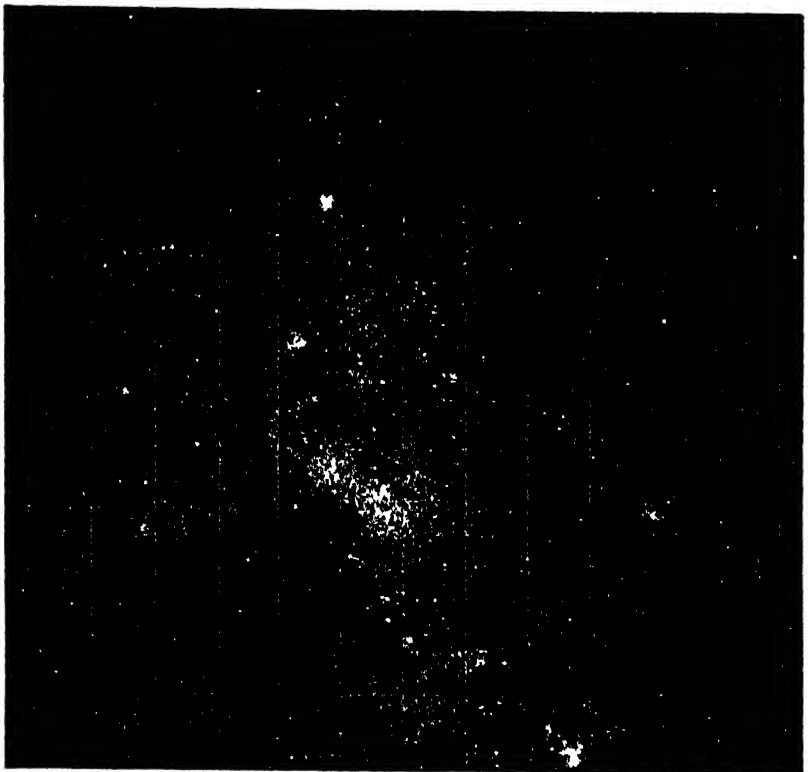
It is interesting to know that the counting of the stars on a plate, a very important operation, is usually done by means of a device known as a billiard marker. It is a small apparatus which is held in the hand and is provided with a spring. On pressing this the numbers shown on the face of the apparatus change by a unit and the count is registered by a series of clicks.

Professor Turner tells us rather humorously that one of the astronomers who was taking a share in the chart had misspent his youth by playing billiards and accordingly knew of this apparatus. He saw how useful it would be for counting the stars in photographs, for while the astronomer was moving the plate under a microscope with one hand he could make the necessary clicks on the apparatus with the other without the necessity of moving his eye from the microscope.

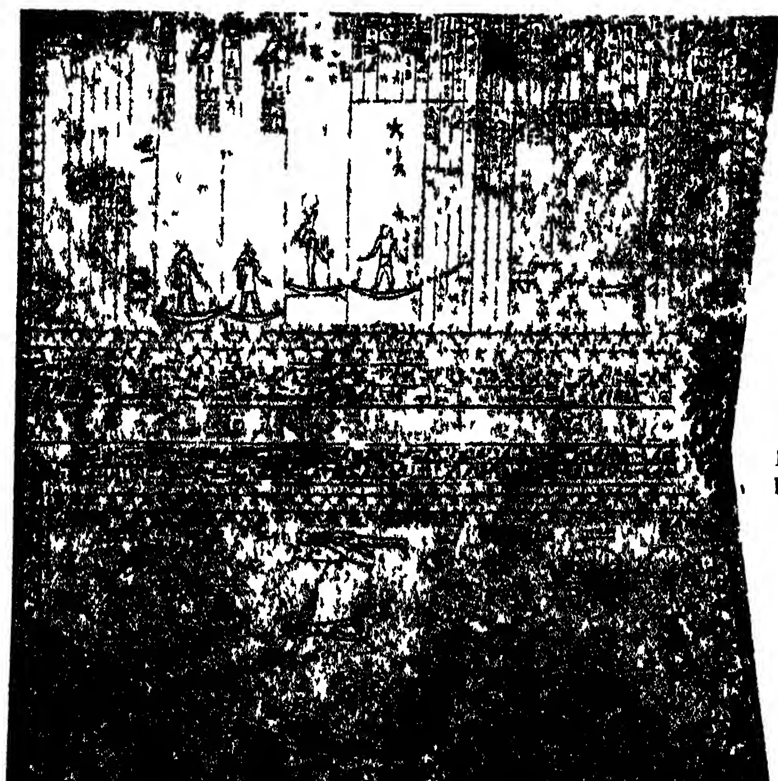
Billiard Markers

Professor Turner says that quite a number of "billiard markers" have been exported to distant astronomical observatories where there are, as a matter of fact, no billiard tables.

The number of stars on the different plates varies enormously. On some there are as many as 5,000, while others show fewer than a hundred. The richer plates are those of regions in the Milky Way.



Part of the great star chart of the entire heavens which is now being made by astronomers all over the world. The chart is divided into squares as shown, and this part, given by courtesy of the Royal Astronomical Society, shows the star cloud in Sagittarius. The difficulty of counting the stars in the map can be imagined



The earliest known star map, made by Egyptian astronomers 3,400 years ago

It was hoped to take a succession of photographs at different times so as to record any changes in the brightness of stars and so on, but unfortunately the expense is so great that only the richer universities are able to carry out the work that was planned to its full extent. In a century's time, however, when probably the whole of the heavens will again be photographed, it may be possible, by comparing the two maps, to detect movements among the stars.

Star Positions

The distances between us and the stars are so great that hundreds of millions of miles and in some cases thousands of millions of miles must be traversed before we can detect any appreciable difference in the position of a star. Some stars, however, are seen to have shifted their position slightly after ten years, perhaps one out of every hundred examined.

A Special Camera

For the taking of the photographs for the great star map a special camera was designed. It is driven by clockwork very delicately adjusted so that it can follow the apparent movement of the stars in the sky corresponding to the actual movement of the Earth, and thus keep the particular section that is being photographed always in the same relative position. If this time camera were not used the stars would appear as lines.

While the popular name of this production is The Great Star Map, astronomers describe it by the much more technical name of the Astrographic Chart. Astrographic is a name made up from two Greek words meaning star and writing.

THE KING OF BEASTS BEFORE & AFTER A MEAL

This fine photograph shows a magnificently maned lion waiting for its dinner. A full-grown lion nine feet long from snout to tip of tail often stands over three and a half feet high, but longer lions sometimes show less height. A menagerie lion that measured ten feet was only three feet two inches high. Lions seem to be deteriorating in size. Nowadays one is rarely found weighing more than 500 pounds, but seventy years ago specimens used to be shot weighing nearly 600 pounds. The male lion in addition to its mane has a brush of long hair at the tip of the tail, and in the middle of this brush at the very extremity is a small horny growth known as the "thorn"

In this photograph we see the same lion after its meal. Animals generally sleep after they have fed well, and this specimen in the London Zoo had eaten a very good meal. In captivity lions are fed on joints of horse-flesh or beef, but in the wild they catch living animals. In Africa they prey upon antelopes, zebras, buffaloes and giraffes. In India they feed on deer, antelopes, wild pigs, cattle, horses, donkeys and camels, while in the oak forests of Persia their staple diet seems to consist of wild pigs. Sometimes they will prey upon carcasses in an advanced state of decomposition, and have even been known to devour elephants that had been shot and were in a state of great decay. Such a meal, however, is rather exceptional; lions prefer to catch their prey alive

THE LION AT HOME AND ABROAD

The King of Beasts is a magnificent animal, and its figure has often been adopted by nations as a symbol of strength and courage. Many qualities, however, have been attributed to the lion which it does not possess, and here we read some facts about this great cat, which should be known by all Nature lovers.

That the lion from his appearance deserves the title of King of Beasts will scarcely be disputed; whether his character and courage are equally deserving is a matter of dispute.

For centuries the lion has been regarded as the symbol of bravery, and men spoke of King Richard the First as the Lion-hearted because that was the best description they could think of for a really brave man.

Dr. Livingstone and other travellers, however, tell us that the lion is anything but brave and daring. Livingstone says that with the aid of dogs he tried to persuade one that he had chased into some reeds to come out and show himself, but the lion refused, and Sir Samuel Baker tells us that on one occasion one of his Arab hunters, meeting a lion, marched slowly forward, when the animal, instead of rushing to the attack, as might have been expected, crept like a coward into the impenetrable thorns and was seen no more.

Another famous lion hunter, Gordon Cumming, with mounted helpers and a pack of dogs, drove a lion for hours from shelter to shelter by a river, and the beast tried to get away by swimming the stream. Other travellers, however, tell a different story and declare that the lion can be both bold and fierce.

Whatever may be the truth about its courage, there can be no two opinions that a male lion, with a fine mane, is the most majestic of all animals, and is a worthy symbol of kingliness. All male lions, however, do not have manes, for there is a maneless lion that is found in Senegal, and looks like a lioness.

The lion is a swift beast, and can for a time at any rate keep up with a galloping horse. One has been seen to start chasing a gnu when it was 1,500 yards away, and soon catch it; and it must be remembered that a gnu is not a slow-moving animal. Generally, however, the lion lies in wait and watches till its prey comes near, when it springs out of its hiding-place behind a rock or in a thicket, and fells the victim with a blow, seizing it with both talons and teeth.

The male lion seems to be a good father and husband, and when the lioness is nursing her cubs he brings his mate and children food. He is also quite bold in defending his household from attack. The cubs when born have mottled skins, but as they grow up the spots disappear, and they become like their parents.

When the family goes out hunting the father leads the way, and it is he who strikes down the victim. But his chivalry then ceases for a time, for generally he growls to keep the family away while he eats his fill, and the lioness and cubs are only allowed to share in the meal when the father has finished.

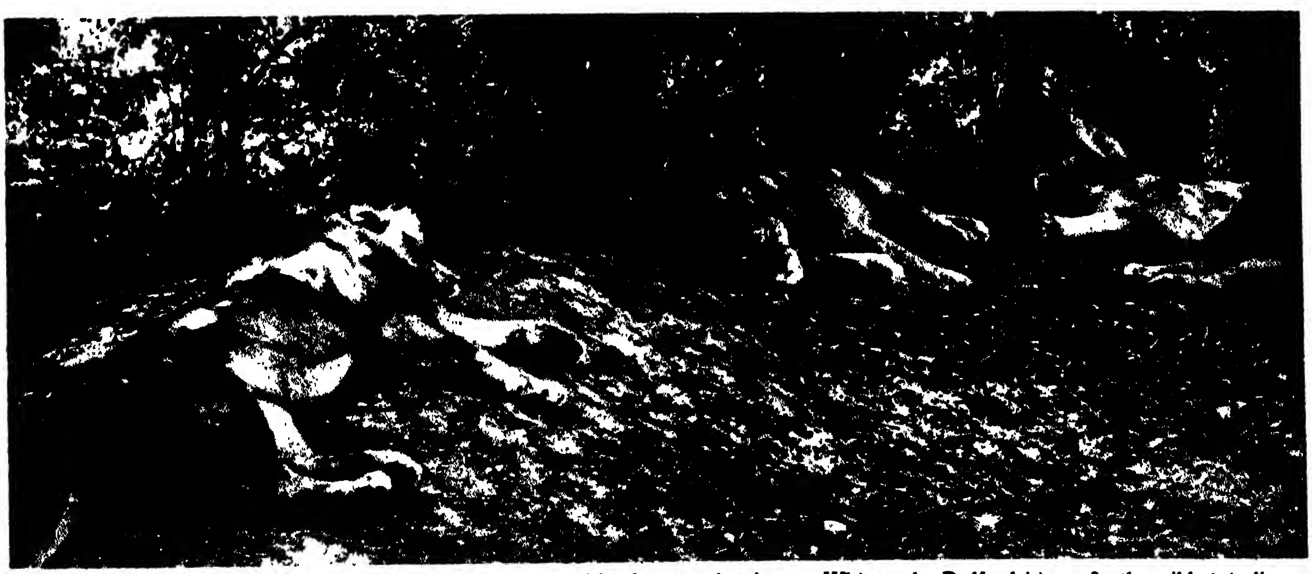
The bones are left to the hyenas and jackals. Sometimes these animals, while finishing up the lion's meal, are themselves pounced upon by the king of beasts and devoured. At times the lion becomes a cannibal and eats his own relations.

At one time lions lived in Europe, and their remains have been found in Great Britain. But that was before history came to be written. At the present time they are found only in certain parts of Africa and in south-west Asia. In living memory, however, an occasional lion has been shot within a few miles of Tangier.

Lion hunting has always been a popular sport, and we find among the ruins unearthed in Mesopotamia many sculptures depicting the Kings of Assyria hunting these animals. Even now lions are found in that country.

It is believed that present-day lions are smaller in size and strength than their ancestors. A lion now measures about nine feet from the nose to the tip of the tail, and weighs about 500 pounds. In captivity it sometimes lives to fifteen years, but wild lions are believed to live for thirty.

The skeleton of a lion is very little different from that of a tiger. The roar of the lion is a fearsome sound but it



When the lion sleeps it usually lies on its side, as seen in this photograph taken at Whipsnade, Bedfordshire. In the wild state lions generally sleep during the day and only go prowling in search of food and drink at night. In captivity the male lion has a much finer mane than he does when wild. Wild lions are very often mangy, and far less impressive than the animals kept in captivity

is not intended to strike fear into other animals it is really a recognition call or challenge to its fellows

Lions rarely attack men unless they are wounded or hungry but sometimes they seem to become man eaters by preference The Game Warden of Uganda says, "When lions collectively take to man killing the taint in their blood is naturally passed on to their offspring though the new generations may not necessarily display man killing tendencies from birth The taint however is lying dormant awaiting an opportunity to display itself"

We have probably heard of the Man-eaters of Tsavo the story of whose escapades was once narrated in the House of Lords They were two animals that held up the building of the railway at Tsavo in Uganda for several weeks in the closing years of last century Night after night they would visit the camp of the native workmen and carry off their victims from the tents eating them close by where the crunching of the bones could be distinctly heard by the terrified comrades of the victims

Colonel Patterson who was in charge of the work tells us that one of the lions entered the tent of his Sikh jemadar who slept there with half a dozen other workmen About midnight the animal put its head in at the open door and seized the jemadar by the throat He shouted "Let go!" and threw his arms round the lion's neck But the animal dragged him outside and then his companions heard a fearful struggle and finally there was silence

The next night Colonel Patterson sat up in a tree near the tent hoping for the lion's return but nothing happened and the next morning it transpired that it had broken into another tent at a camp some distance away and carried off a sleeping workman The colonel on the following night therefore took up a position near this tent but the lion seized a victim elsewhere

The various camps were scattered over a distance of some sixteen miles and the cunning lions seem to have made a practice of visiting a different camp each night

One man had a marvellous escape He was asleep in his tent when a lion broke in and seized not the man but the mattress on which he was sleeping and made off with it the man receiving nothing worse than a fright

After another man had been dragged from his tent and carried off by a lion the colonel and a companion had a goods wagon moved to a siding and decided to sit up and watch for the marauder The officers entered the wagon and had the lower half of the door closed but left the upper half wide open so that they could see out For an hour or two all remained quiet and then about midnight a twig was heard to snap A moment later there was a dull thud, as though some heavy animal had jumped over the fence

It was very dark and Colonel Patterson proposed to go outside and lie down on the ground so that he could see better should a lion come in the direction of the wagon His companion however persuaded him to remain inside and fortunate it was that he did so for at that very moment although neither knew it the lion was stalking them

Both men thought they could see a dark object moving outside but said nothing There was intense silence for a second or two and then with a sudden bound a huge body sprang at the open doorway

"The lion!" shouted Colonel Patterson and both men fired simultaneously Not a moment too soon for in another second the brute would assuredly have landed inside the wagon

On one occasion a lion held up a railway station so that a train could not start, the stationmaster and signalman barricading themselves in the station building for many hours Eventually the two man eaters who had been responsible for such a reign of terror as to cause a strike of the workmen, were killed, but only after many crack shots had been enlisted to assist in the hunt The lions had the honour of being referred to in the House of Lords by Lord Salisbury, the Prime Minister, who told the story of how they had held up the work of the Empire for three weeks

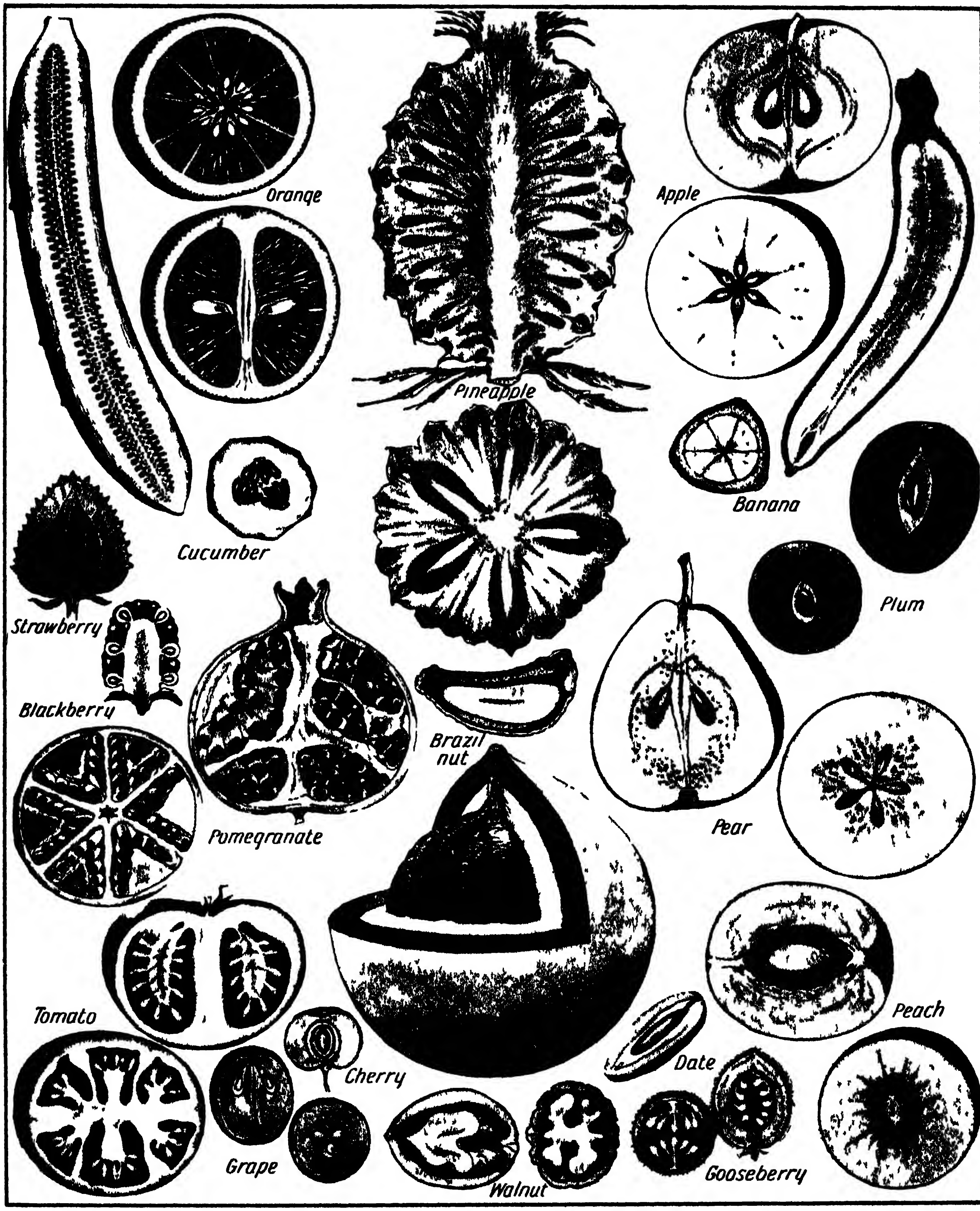
A striking photograph taken from an air mail aeroplane travelling between Casa Blanca in Morocco and Dakar in Senegal The solitary animal was making its way across the sand among the mountains of Southern Morocco and its footprints can be clearly seen The pilot observed the lion while looking out and came down below his normal flying height in order to obtain a good photograph

THE LION AS SEEN IN ITS NATIVE HOME

In these pictures we see what the lion looks like in its native home The animals were photographed by a film unit working in the African jungle The mane of the male lion does not appear till the animal is abou' hree years old, and it goes on growing till the animal is about six The lion lives among thick beds of reeds or in bush thickets At sundown it sets out foraging and is most active on dark, stormy nights On moonlight nights it is far more cautious Livingstone declared that while the roar of the lion inspired no awe in a person who was snug in a house or wagon, the sound was calculated to inspire fear when heard in a dark night amid the tremendous peals of an African thunderstorm, and the vivid flashes of lightning

It was long stated that the lion never climbed into a tree and many a traveller's life has been saved by ascending a tree into which the lion did not follow. But photographs like this one suggest that the lion does at any rate sometimes climb into the lower branches. The picture is a still from a nature film, and shows a family of lions in the long grass. Although in some districts lions are met alone or in pairs, this is not generally the case in Africa, where from five to a dozen lions are frequently seen together

WHAT FAMILIAR FRUITS ARE LIKE INSIDE



On this page are given pictures showing what eighteen of our familiar fruits are like inside In most cases double sections are given, that is, each fruit is shown cut down longitudinally or the long way, and also cut across In the case of the strawberry, blackberry, Brazil nut, cherry and date, longitudinal sections only are given Brazil nuts are really sections of a fruit which is large in size and has a very hard case outside , in fact, a Brazil nut falling from a tree on to a man's head might stun him The Brazil nuts in their shells which we buy in the shops are packed inside this hard case something like the sections of an orange The pips and kernels of fruits are seeds

MARVELS of MACHINERY

A SIMPLE MACHINE USED EVERYWHERE

The chief occupation of man is work, the term being used in its broad sense of doing things, whether it be to earn a living, as when he works in a factory, or whether it be to gain pleasure as when he kicks a football or strikes a golf ball. Work is, from a scientific point of view, the application of effort and the expenditure of energy for any purpose. To help him in his work man has invented many ingenious devices, and none is more valuable than the pulley, which is really a variation of the lever, and is described here

VERY early in the history of man he discovered that he wanted to do all sorts of things which were impossible without some aid. Imagine a man of the Stone Age finding a fallen tree by a river bank and deciding that he would make a boat.

He had already invented the stone axe and knife, and with these in course of time he would hollow out a place in the trunk in which to sit. It was his primitive idea of a boat. There was his boat lying on the river bank, but how was he to get it into the river? He would push and tug, but the dug-out boat would be far too heavy for him to move. So he would call a number of his fellows, and by pushing and pulling together they would perhaps manage to get the boat into the water. This, however, was a very primitive way of doing such a piece of work.

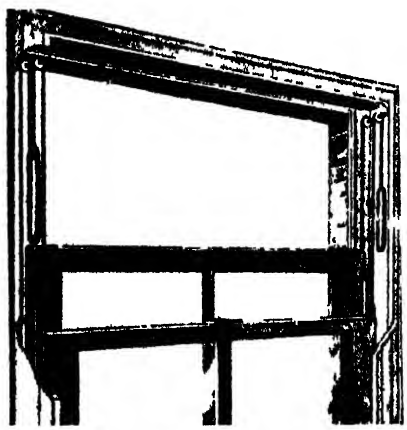
By using a bough as a lever man would make the task of getting the boat down to the water much easier. But useful and necessary as the lever is, coming as it does again and again into all kinds of complicated machines, there were times when the ordinary lever would not serve the purpose at all.

A man with a crowbar can raise a heavy weight a little off the ground, but if he wants to raise a heavy weight thirty or forty feet the crowbar or lever is of no use. He needs some other device, and that device he has invented in the pulley.

What is a pulley? Well, it consists of three parts. There is first a plate or disc or wheel, with a groove cut all round its circumference and able to move freely on an axis. This wheel is called the sheave. Then there is a piece of wood in which the wheel is placed and to the sides of which the axle of the wheel is fixed for support. This is called the block.

Finally there is a cord which passes over the groove in the sheave, and this is called the tackle.

Let us take the simplest kind of pulley, and see how it works. It must be explained that pulleys are of two kinds known as fixed pulleys and movable pulleys. Now the simplest kind of pulley is a single fixed pulley.



Here is a familiar example of the use of the pulley for domestic purposes. The sash-lines of windows work over pulleys

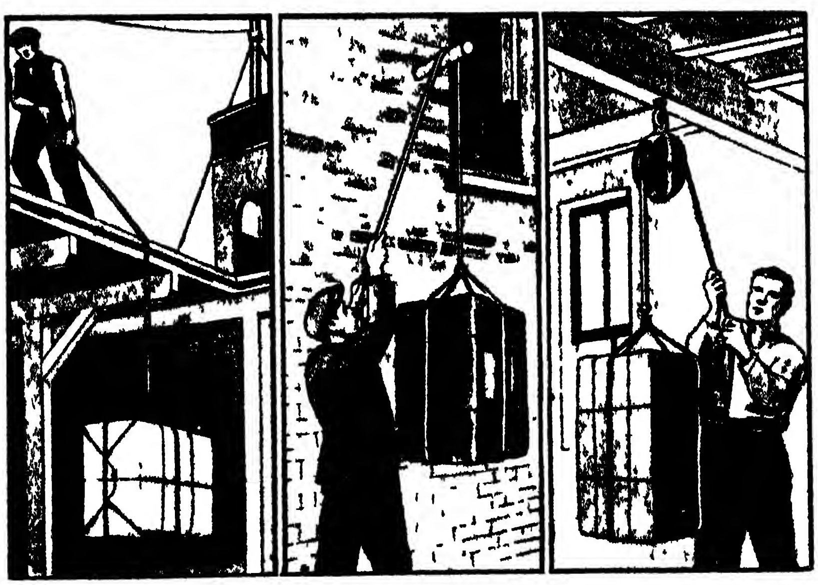
In the garden there is perhaps a tall line post and the maid wants to pull up the line on which the clothes are hanging on washing day, so that they may be sufficiently high up to catch the wind. How does she get the line high enough? One way would be to take a very tall pair of steps, place this against the line post and, going up the steps with the line, fix it to the top of the post. But that would be a very clumsy way of doing the work.

The task is made much simpler by means of a single fixed pulley. The pulley is attached to the top of the line post, the cord or tackle passes over the wheel of the pulley and hangs down, and all the maid has to do to raise the line of clothes is to pull the rope till the line reaches the desired height, and then tie it or fasten it in some way so that it cannot run down again over the pulley.

What advantage has the pulley given to the maid? It has not lessened the force which she has had to exert in pulling up the line of clothes. The advantage the pulley has given her is that it has changed the direction of the force which she has had to exert.

Instead of going up the steps and pulling the line after her, the maid has been able to remain below and pull the end of the line down. By passing the line over the pulley, the downward pull at one end has caused an upward pull of the line on the other side of the pulley.

The cord is flexible but not elastic, and the force which is brought to bear by the maid on one part is communicated to every other part, so that if she pulls with a force equal to 100 pounds on one end, this is communicated right through the cord



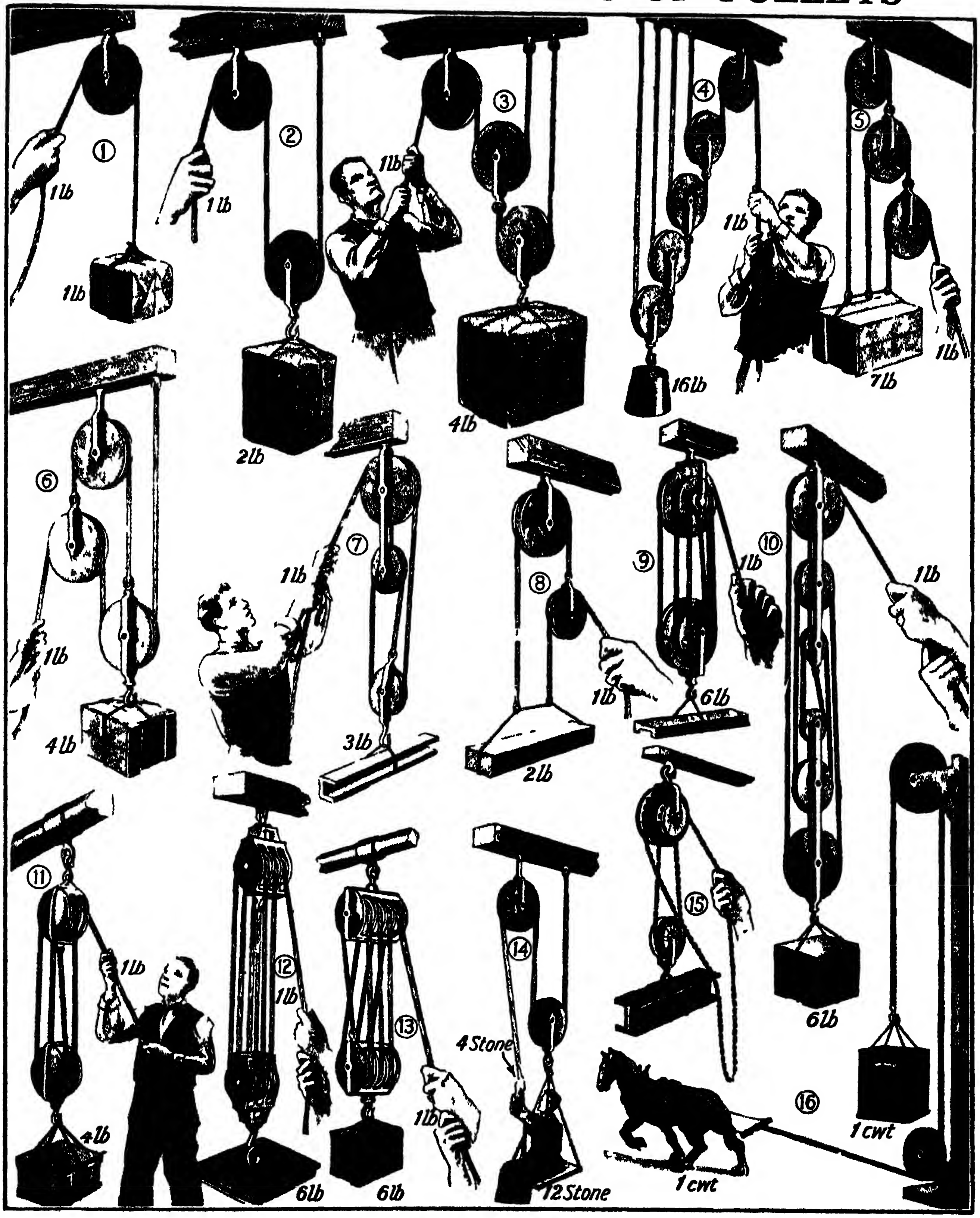
These three pictures show three stages in the evolution of the pulley. In the first picture the man is hauling a heavy load to a higher level. In the second he has made the work easier by throwing the rope over a projecting beam and pulling down instead of up. In the third picture, by using a pulley, he eliminates a great deal of friction besides changing the direction of the pull

THE PULLEY ON A LARGE AND SMALL SCALE

The pulley is used every day on both a large and a small scale. In this picture we see it in operation on a poultry farm, where by its means a heavy engine is being removed from an old motor-bus, because the bus itself is to be fitted up as a chicken pen. As explained in these pages, the pulley makes it possible for men to do much more work than they could without its aid.

Here we see the pulley in use on a large scale in a huge crane, which is lowering a 28-ton girder into position for the building of a new bridge. Not only is the pulley giving mechanical advantage, but it has enabled the direction of the pull to be changed more than once

MANY DIFFERENT KINDS OF PULLEYS



On this page we see all sorts of pulleys, and the figures showing the force exerted on one side and the weight lifted on the other, indicate the mechanical advantage obtained by the use of each In No 1 the pulley merely changes the direction of the pull Where the weight is much greater than the pull exerted the pull has to be made through a much greater distance than the weight rises For example, in No. 4, where one pound balances 16 pounds, to raise the weight one foot the pull must be exerted through 16 feet. Where mechanical advantage as well as change of direction is wanted the type of pulley used is that shown in Nos 9, 11, 12, 13 and 15

This simplest form of pulley may often be seen in use when a house is being built. For instance, instead of a labourer carrying the bricks in a hod up the ladder on his shoulder, it is very usual to put the bricks in a basket, attach this to a hook on the end of a line, pass the line over a pulley, and then pull on the other end from the ground. In this way the bricks are raised quickly and easily to a great height.

The pulley, as we have seen, is very useful for changing the direction in which a force is exerted, but it has also another great advantage. By a combination of pulleys we are able to obtain a gain of power; that is, we can raise a great weight with a little force. We perform the feat by using not only a single pulley, but one or more fixed pulleys and one or more movable pulleys. We will first consider the use of a single movable pulley.

The Movable Pulley

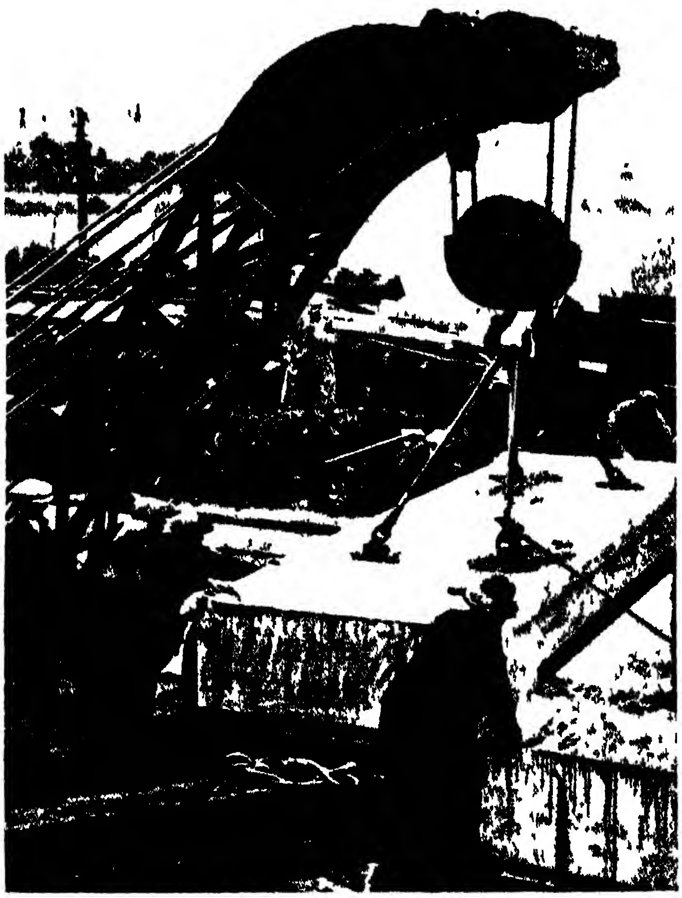
A cord is fastened to a beam and passes round the groove of a movable pulley. A man holds the other end of the rope. He will find that by exerting a certain power he can raise double the weight. We can understand this if we think the matter out.

The reason is that half the weight is supported by that part of the cord fixed to the beam, while the other half is supported by that part of the cord which the man holds. This use of the movable pulley, however, is not of very much value, but it can be made of very great value by running the cord over a fixed pulley attached to the beam, as shown in the second picture on page 651. The movable pulley has halved the power which has to be exerted to support the weight, while the fixed pulley has enabled the force to be exerted in a downward instead of an upward direction.

But if we use a pulley of this kind something at once strikes us in addition to the fact that we have gained power. We shall notice that for every two inches that we pull down our end of the cord, the weight rises only one inch. This is of course because the two inches gained on our end of the cord is divided between the two cords on each side of the movable pulley. As we lengthen our cord by two inches, each of those cords is shortened by one inch, and so the weight is raised only one inch.

This is the great principle of the pulley which makes it such a very valuable tool. We gain in power what we lose in distance, and by using a number of fixed pulleys and a number of movable pulleys, each generally fixed side by side in one block, we are able by the use of very little force through a great distance to lift a very great weight through a short distance.

We may have stood in the streets of a city and seen a heavy steel safe being raised to the fourth or fifth floor of an office building. A powerful pulley is attached to a beam which is securely fixed at the top of the building.



A large railway crane with its huge pulleys lifting a 15-ton block of concrete into position for the construction of a new bridge

The chain or steel cable, attached to the heavy safe, which sometimes weighs many tons, passes round and round the sheaves or wheels of the pulley, and then one or two men on the pavement, by pulling the end of the chain or cable, are able to raise the safe higher and higher. But we shall notice that while they pull a great deal of chain at each tug the safe rises only a few inches at each pull.

Let us see the principle on which this work is done. The eighth picture on page 651 will help us. Here there are two pulleys each with three blocks, one being fixed and the other movable. As there are six strings, three on one side of the sheaves and three on the other side, it is clear that for every six inches that the loose cord is pulled down the weight will rise only one inch, but the power exerted to support the weight will be only one sixth of that weight. Thus, if the weight is sixty pounds, a power or weight of only ten pounds on the loose end of the cord will support that heavy weight, and a little more power will pull the weight up.

The use of the pulley in different forms will be seen in the various kinds of cranes. Sometimes a single fixed pulley is placed in the arm of the crane, and is merely used to change the direction of the power. In others much more complicated pulleys are used.

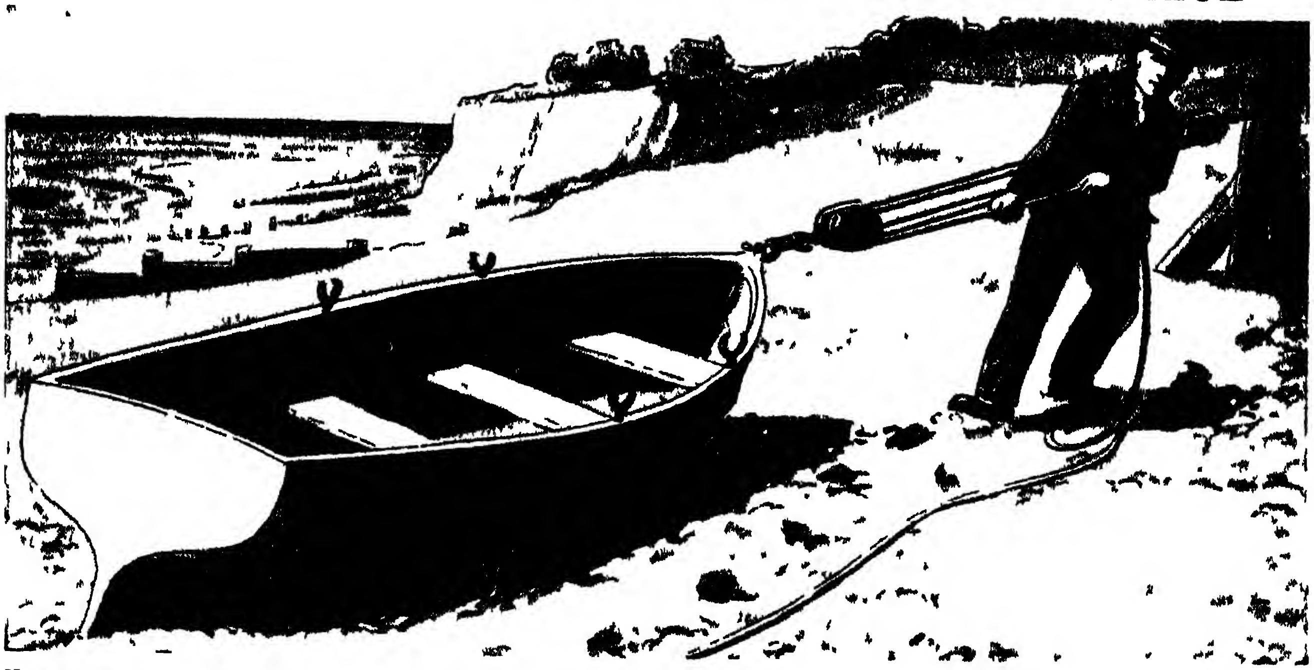
One other thing must be mentioned. In all our talk about the pulley we have not taken into consideration the actual weight of the movable pulleys and the friction that occurs. We have merely referred to the mechanical advantage of the pulley itself. In actual practice some of the mechanical advantage of the pulley is lost owing to the friction of the cord on the sheaves and the friction of the sheaves as they turn on their axle. Also the weight of the movable pulleys must be added to the weight we are raising. Those facts, however, do not affect the principle of the pulley, one of the most wonderful and useful devices that man has ever invented.

The Three Systems

It should be explained that pulleys are divided into three separate systems according to the way in which they are combined. In the first system each pulley hangs by a separate cord and each cord has one end attached to a fixed point in the beam, while all except the first have the other end attached to a movable pulley. Examples of the first system are seen in Nos 1 to 4 on page 651. In the second system the same cord passes round all the pulleys, and examples of this are seen in Nos 9 to 13. This system is very generally employed because of its compactness and the ease with which the pulleys can be moved. In the third system each cord is attached to the weight or to the bar from which the weight hangs, while the other end supports a pulley, as in No 5 on page 651. An advantage of this system is that the weights of the movable pulleys assist the power instead of acting against it.

Who first discovered the pulley? We do not know, but if we did, every nation should put up a monument to honour his memory.

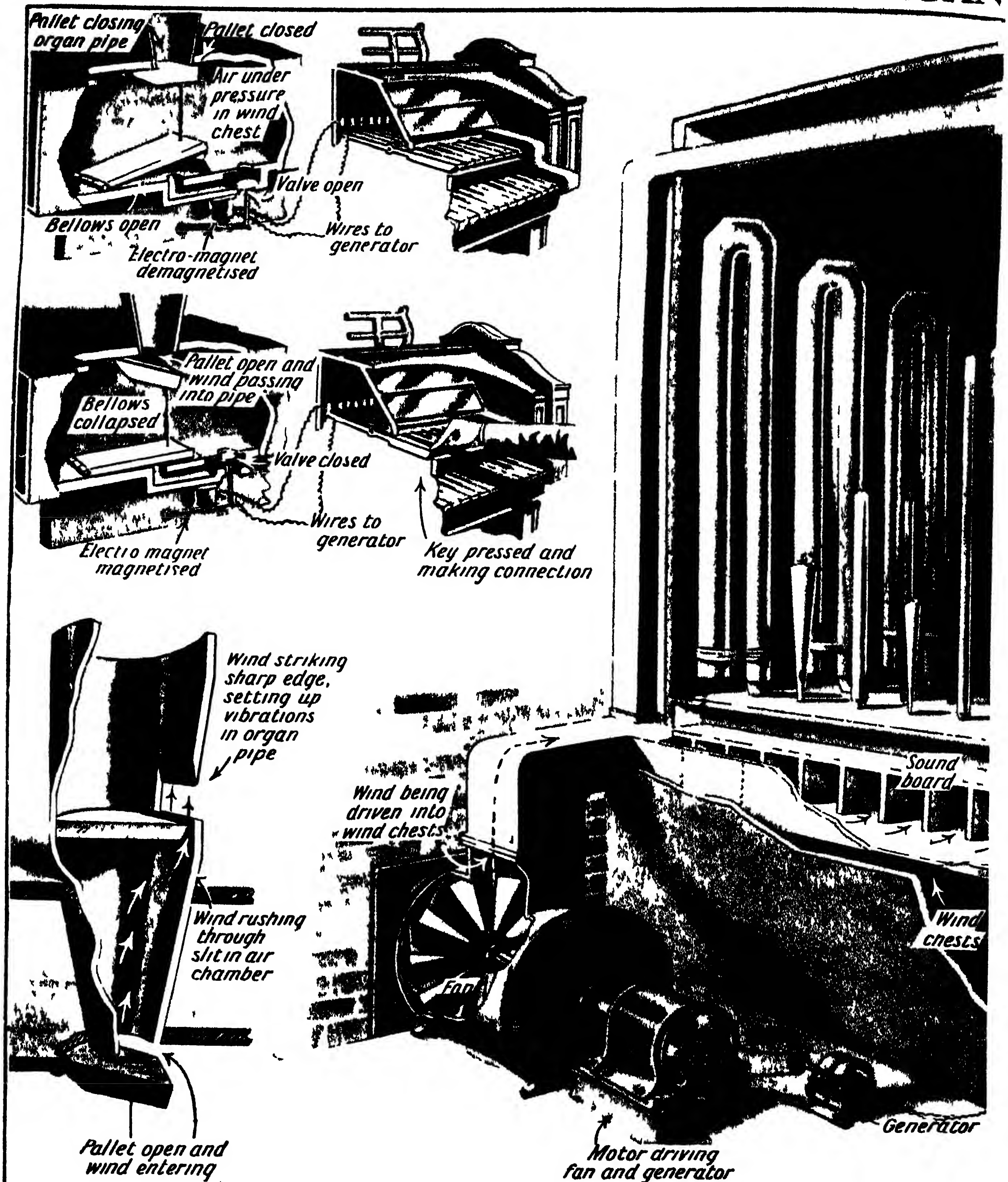
EXAMPLES OF THE PULLEY'S MECHANICAL VALUE



Here is a very familiar example of the use of the pulley as seen on the beach at many seaside resorts One man could never pull up a large rowing boat such as is shown in the picture without aid By using a fixed and movable pulley, with one or more wheels in each, he can gain such a mechanical advantage that he is able without any other assistance to drag the boat right up the rough sloping beach The fixed pulley is, of course fastened to a strong post embedded in the upper part of the beach

This picture shows a curious and amusing experiment that is well worth carrying out Four men or older boys arrange themselves in pairs, each pair holding firmly to a broom handle or stout pole To one of the poles is tied the end of a strong rope, and the rope is then passed round and round the poles till there are three loops round each and six cords between them The end of the rope is then taken in hand by a boy, who declares that he will draw the pairs of men together no matter how much they may pull and struggle to keep apart The men on each side pull hard, but the boy pulls also, and slowly but surely he draws the pairs of men together The explanation, of course, is that the principle of the multiple pulley has been brought into play If, for example, as in the picture, there are three loops on one side, corresponding to three movable pulleys, the boy by exerting a force of 8 stones can balance a force equal to 48 stones and with little more exertion can overcome the attempts of the men to keep apart Of course, there may be more loops

THE INSIDE OF A LARGE CINEMA ORGAN



Here we see how a large cinema organ is worked electrically from a keyboard, wires going from the various keys through a thick cable to the organ, and passing through the connection box on the way When the organist presses down a key the electric connection is made and wind is let into a particular pipe producing the sound required As we see in the big centre picture, a motor worked by electricity turns a fan and drives wind into the wind chests under the organ At the same time the motor drives a little generator which supplies the necessary electricity to the wires connecting the keyboard with the organ The pictures on the left show the process of producing a sound in an organ pipe At the top we see how, when the key working this pipe is still there is no electrical connection, and the iron in the little electro-magnet is not magnetised The small lever underneath it is, therefore, not drawn up, and so the valve of the wind chest remains open, allowing the wind under pressure to enter through a small aperture into a bellows The wind opens the bellows and so pushes up a little pallet, closing the organ pipe In the second picture the organist's finger is seen pressing down the key This makes the necessary connection at the back Electricity passes through the wires and the iron of the electro-magnet is magnetised At once it draws up the lever underneath, and this pushes up the valve, closing the opening in the wind chest Immediately the bellows collapse, as there is now no wind to blow them open, and in doing so they pull down the pallet, which permits the wind to pass into the

AND HOW IT IS MADE TO PLAY TUNES

pipe. At the bottom we see on a larger scale what happens in the pipe. The wind rushes up through a slit in the air chamber and strikes upon a sharp edge placed just above the opening. Vibrations are started which run up the pipe, causing a sound The different notes are produced by different length pipes, and the longer pipes are bent round so as to take up less space. On the right we see how the various instruments connected with the organ, such as drums, cymbals, triangles, piano and so on, are played The method is similar in all cases, but the drum is taken as an illustration When the organist presses down a key to play the drum the bellows in the wind chest collapse and pull away a pallet The wind then blows out a bellows on the other with which a drum-stick is connected, and as it goes out it moves the drum-stick which strikes the drum. When the organist releases the key wind deflates the other bellows and closes the one with which the drum-stick is connected The same thing is done when the cymbals are to be clanged together, a piano-string tapped, or the bells or triangle struck. Each piano string has its own hammer, worked by a pallet and bellows Swell shutters control the volume of sound of the organ, and these are worked by the organist pressing on three boards with his feet As he does so wind passes into a large bellows at the top, which becomes deflated, raises a rod connected with the swell shutters, and opens them like the leaves of a venetian blind. Then the music gets louder When the player removes his feet the bellows collapse and the swell shutters close

HOW THE ICE FLOATS AND FORMS A SHEET

It is a very fortunate thing for people living in the northern and southern regions of the Earth, where the temperature often falls below freezing point, that ice is lighter than water, and floats, as shown in this winter picture of the Grand Junction Canal. If the ice sank as it formed the British Isles would probably be uninhabitable, for the seas surrounding them would, in all probability, be frozen solid

When a frost lasts for several days bodies of still water, such as ponds and lakes and even sluggish rivers, become covered with a sheet of ice. At first this is thin and will not bear much weight, but if the frost continues the ice gets thicker, and will soon support a considerable weight, so that people can skate over the surface. In England it is not often that the ice is strong enough for skating, but covering Greenland is ice a mile thick. Here we see the lake in Regent's Park, London, frozen over, and the swans and ducks being fed

A VERY STRANGE THING ABOUT ICE

Here are some interesting facts about ice which everyone should know. At certain temperatures water behaves very curiously, and it is this fact that brings both trouble and benefit to mankind. If ice did not float a large part of the world would be in a sorry plight as we shall see

WE are familiar with the fact that in frosty weather water freezes into a solid form, which we call ice. This happens at 32 degrees Fahrenheit, or at 0 degrees Centigrade, and we call these points on the two thermometers "freezing-point."

This is a very different temperature from that at which other substances become solid. Cast iron, for example, remains solid until it reaches a temperature of 1,150 degrees Centigrade, that is a very great heat. Even lead is solid until it reaches a temperature of 325 degrees Centigrade, but mercury or quicksilver remains liquid till it reaches a temperature very much colder than that at which water freezes into ice. Mercury does not become solid till it has reached a temperature of 38·9 degrees below zero, Centigrade.

Now there is a very remarkable fact about water which is responsible for a good deal of trouble in our homes, but is at the same time a very great boon and blessing to mankind. These statements seem strangely contradictory, but they are nevertheless both true, as we shall see.

Bursting a Balloon

Most substances as they get cooler contract and occupy less space, and as they get warmer they expand and occupy more space. There are many familiar examples of this which we come across. If, for instance, we blow out a balloon and then tie it up so that the air cannot escape, and hold it near a fire or put it in the warm sunshine, the balloon will gradually get bigger and bigger till at last the skin cannot stretch farther without breaking, and there is an explosion. This is due to the fact that the air inside the balloon has become warmer and has consequently expanded. At last it needed so much space that it burst the balloon.

Another familiar example is to be seen on the railway track. We notice that the rails are not put end to end quite flush. There is a little space between the rails, and this is to allow for expansion in hot weather. As the summer sun shines upon the rails they become hot and swell. If there were no space left to allow for this expansion they would either press against one another till they buckled, or they would become detached and disarranged.

Now water is one of the few exceptions to this general rule that the colder a substance becomes the less space it occupies, and the hotter it becomes the more space it takes up. It follows the rule for most of the time; for example, when we boil a kettle of water, as it gets hotter it expands, and when it turns into steam it expands still more.

Contraction and Expansion

Similarly, in cold weather, as the water gets cooler and cooler it contracts. But suddenly when it reaches a temperature of 4 degrees Centigrade, that is, 39 degrees Fahrenheit, it begins to do what you would certainly not expect. Instead of going on contracting it begins to expand. At 4 degrees Centigrade its molecules are packed more closely together than they are at any other temperature, or in other words, the water has contracted to the smallest space it can occupy. As it gets colder it expands more and more until at last, when it reaches freezing-point (0 degrees Centigrade or 32 degrees Fahrenheit) it becomes solid, and we say that it is ice.

Perhaps we may never have thought before of the fact that ice is really a rock. We know that round the coast of Cornwall and Aberdeen there are granite rocks which are very hard, but at a certain very high temperature even these would melt and become liquid, just as ice does. Greenland is similarly covered with rock, but in that case the rock is ice.

We speak of water at 4 degrees centigrade as being at its maximum density. This can be proved by experiment. We can take a flask or jar and insert a cork with a narrow glass tube passing through it, the jar being made air-tight. We then fill the jar with water, so that the liquid will rise a little way in the tube.

Now, if we place the jar or flask over a lighted spirit lamp the water will rise in the tube as it gets warmer, because it is expanding. By the way, before it begins to rise it will sink a little way, this curious fact being due to the expansion of the glass flask or jar. If we heat the water sufficiently the fluid will rise in the tube till it overflows.

Here is an interesting experiment which was carried out many years ago at Quebec. Two bombs were filled full of water and sealed up. They were left out in the open air all night during an intense frost, and the water inside became ice. In one case the plug of the bomb was shot out, and a column of ice projected, while in the other case, where the plug was more securely fastened, the bomb itself was cracked all round and a ring of ice forced out

How Water Freezes

Now let us put the jar aside till the water has become quite cold. We then stand it in a freezing mixture composed of pounded ice and salt. The water in the tube will at once recede, but when it approaches 4 degrees Centigrade it will suddenly become stationary, and then will begin to rise once more in the tube. From 4 degrees Centigrade to freezing-point, that is, from 39 degrees Fahrenheit down to 32 degrees, the water will rise more and more in the tube, and then at the actual moment of freezing-point, when the liquid becomes solid ice, its expansion is somewhat sudden.

It is this remarkable fact about water that causes our pipes to burst when there is a frost. The leaden pipes which carry the water about the house are, of course, full of water, and as the weather gets colder the water contracts, but the pressure at the main or from the cistern keeps the pipes full.

Then at 4 degrees Centigrade (39 degrees Fahrenheit) the water suddenly begins to expand and it continues to do so till at freezing point it becomes solid ice

It is in the last sudden expansion as it becomes solid that the pipes are usually burst At first the lead can resist the pressure but this becomes so great at the moment of freezing that unless the pipes are very strong they give way

Iron pipes are not usually burst as they are strong enough to resist the pressure of the small stream of water running through them But even iron can be burst by ice for the amount of expansion is found to be about 10 per cent or in other words a thousand cubic feet of water at freezing point become 1 102 cubic feet

Ice Bursts a Bombshell

Many years ago a Major Williams made some interesting experiments to show the power of expanding ice during a severe winter at Quebec in Canada He took an iron bombshell about three quarters of an inch thick and filled it with water Then he carefully plugged up the opening and left it out on the ground When the water froze the plug was hurled out to a distance of 330 feet while at the same time a cylinder or rod of ice 8½ inches long projected from the opening This was of course due to the expansion

Major Williams then took another bombshell and fixed the plug into this more securely than he had done with the previous one In this case the plug remained in position but the bomb was burst right round its circumference and a ring of ice was forced through the rent

We can understand then why it is that our waterpipes are so often burst during a hard frost A slight frost of course does not get through the pipe to the water which therefore remains liquid

When the Pipes Actually Burst

People often speak of their pipes bursting when the thaw comes but of course that is not the case They burst when the water becomes ice and the rent is only discovered when the ice changes back into the liquid form Then the water pours out of the opening

It will be seen therefore that the fact of water expanding as it freezes is often a great nuisance But we said also that it was a great boon and this must now be explained

Seeing that water expands when it freezes ice is obviously lighter than water We can prove this for ourselves by dropping a piece of ice into a tumbler of water So in ponds and lakes and rivers and also in the sea it floats instead of sinking to the bottom At last if the frost continues the surface of the body of water becomes frozen over

What really happens is this First of all, the surface is chilled by the cold air above it and becoming heavier than the warm water beneath it sinks while warmer water from below rises to take its place This goes on for some time, there being a regular circulation between the bottom and the top of the lake or river

Then when the whole body of water is reduced to 39 degrees Fahrenheit or 4 degrees Centigrade the circulation stops for as the surface water becomes colder it begins to expand and so is lighter It therefore remains on top till it actually turns into ice, and this floats If the frost is intense enough and the temperature low enough the whole surface will become frozen into a sheet of ice

Ice floats in fresh water with one-tenth of its bulk above the surface

An iceberg in the sea floats with one-ninth of its bulk above the surface

If Water Went on Contracting

Now observe how useful to us this remarkable behaviour of water is The sheet of ice across the surface of a lake or river acts as a blanket and unless the frost is very hard and prolonged the water below remains liquid Of course in intensely cold areas a lake may freeze for a considerable distance down

Suppose now that water behaved like most other substances and as it became colder went on contracting even to freezing point and below What would happen? The first ice formed at the surface through contact with the cold air would sink to the bottom Other ice would form on top and also sink and if the frost continued at last the lake or river would become frozen right through from top to bottom

How Britain Might Have Frozen Seas

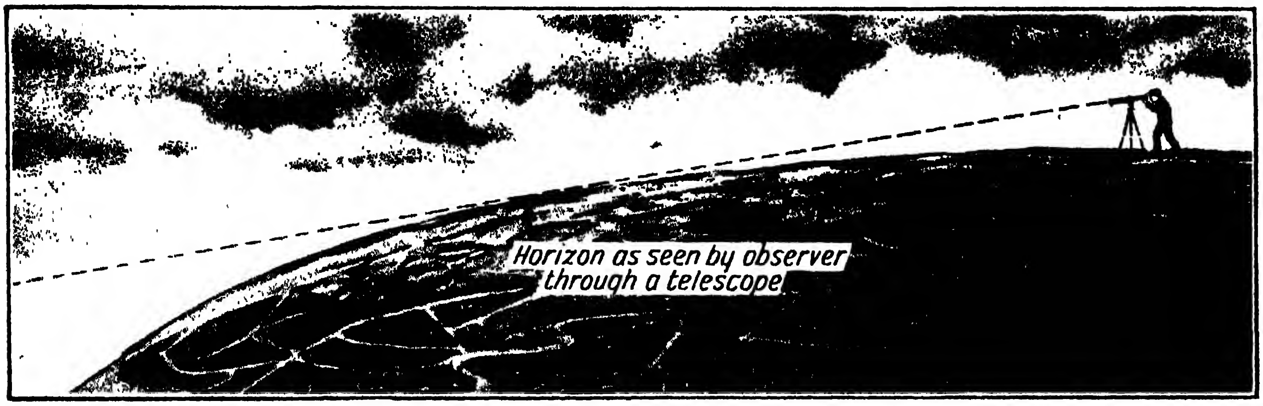
In northern lands like the British Isles this would happen in cold winters When the summer came the surface of the frozen lakes and rivers would melt, but as water is a bad conductor of heat the warmth would not get far down, and so only an inch or so at the top would become liquid Then during the next frosts this would again freeze solid We should therefore, have probably in the northern temperate regions solid masses of ice in our rivers lakes and even seas By the useful provision of Nature, which says that water shall begin to expand near freezing point we are saved from this calamity The expansion of water on freezing is due to the particles rearranging themselves so as to enclose larger spaces between them Why exactly the water changes its habit and expands at 39 degrees Fahrenheit no one can say

Ice floats in fresh water with about one tenth of its volume above the surface, but as sea-water is denser that is, heavier, bulk for bulk, than fresh water, icebergs float with about one ninth of their volume above the surface It seems wonderful that some of those huge icebergs which float in the polar regions have eight times as much submerged as can be seen above

Sea-water freezes at a temperature of 26 degrees to 28 degrees Fahrenheit, the temperature varying according to the saltness of the water.

HOW WE SEE THAT THE EARTH IS ROUND

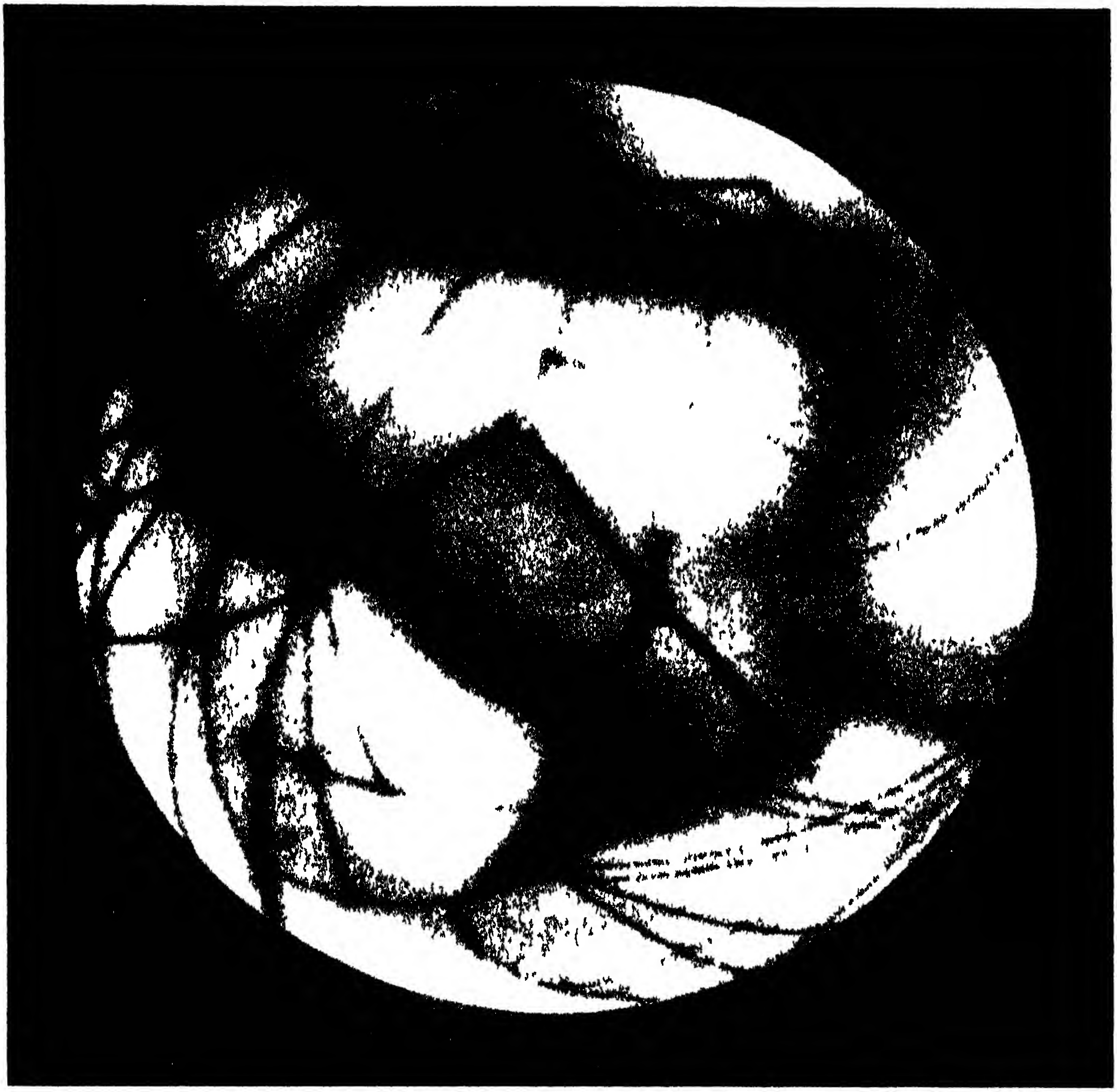
A number of proofs that the Earth is not a flat plain were given on pages 356 to 358, but there are still other proofs. This picture and the one underneath show that there is a limit to the istance which can be seen from any given point. Here we suppose a man to be looking at the far horizon. The arrow marks the limit of the distance to which he can see with his naked eye



If now the man, looking at the horizon, secures the aid of a telescope, still standing in the same position, he can see no farther along the Earth's surface. If the Earth were flat he would, of course, see many miles farther than when he looked with the naked eye, but the curvature of the Earth, as can be seen by the dotted line, prevents the telescope from showing him any more land or sea

Here is another proof that the Earth is not flat. Occasionally travellers on high mountains when the Sun is rising behind them can see the shadow of the Earth thrown upon the distant mist, which forms a kind of screen. This shadow is seen to be curved, and the curve is due to the rotundity of the Earth's surface. This, of course, is not a proof that the Earth is a sphere or ball, but it is a definite proof that the surface curves, and is not flat, as used to be supposed long ago

THE PLANET MARS AND ITS STRANGE MARKINGS



The planet Mars is the most interesting of all the Sun's family of worlds, for we are able to see its surface with some distinctness, this not being shut off from our view by dense clouds, as in the case of some of the other planets. Mars shows us a more or less ruddy disc, and for this reason it is often called "the red planet" There are white patches at the planet's poles, which are known as the "polar caps," and are supposed to be masses of snow or ice, or possibly frozen carbon-dioxide In the planet's summer these become smaller, and then certain lines seen all over the surface become more distinct Some astronomers have supposed that the lines are water channels or "canals" made by intelligent beings, and that their increased distinctness at certain seasons is due to vegetation

Mars is very small compared with the Sun, as can be seen in this picture-diagram, which shows the planet as a round dot on a part of the Sun's disc drawn to scale Mars at its greatest distance is 154,860,000 miles from the Sun, and at its shortest distance 128,440,000 miles. While the Sun is 867,000 miles in diameter, Mars is only 4,352 miles or little more than half the diameter of the Earth

ALL ABOUT MARS, THE RED PLANET

Even people who take little interest in astronomy often ask the question whether there is life in other worlds besides the Earth. In our present state of knowledge it is impossible to say, but many astronomers have considered that on the planet Mars they have discovered not only indications of vegetation, but signs that suggest the work of intelligent beings. We know more about conditions on this planet than on any other member of the Sun's family of worlds, and here we read much about Mars that is of absorbing interest to all of us

MARS is one of the best known of all the planets. There have been so many stories written and so much discussion about intelligent beings on this planet that people who care nothing for astronomy have developed an interest in it. But even from an astronomer's point of view it is perhaps the most interesting of all the Sun's family of worlds.

It is the next planet in order outside the Earth's orbit, and although it does not come so near to the Earth as Venus, yet we are able to examine it much better, for while Venus at its nearest turns its dark side to the Earth, Mars when it is nearest shows us a fully illumined face.

There is another reason why we know more about Mars than we do about Venus, and that is that Mars has a much thinner atmosphere and its face is not covered with clouds, as is the case with Venus. The result is that we can see the actual surface of Mars.

Its character has given rise to interesting speculations, and some astronomers have believed that they could see in the markings on the planet evidence of the work of intelligent beings. We must, however, not jump to conclusions, and must remember that any ideas about living creatures on the neighbouring planet are purely speculations, with no definite proof.

First of all, let us get some idea as to the size of Mars, and its distance from both the Earth and the Sun. This planet, which at its nearest is 33,916,000 miles from the Earth, and at its greatest distance 249,384,000 miles, is less than a fifth the size of the Earth. In mass or weight it is only a fraction over a tenth of that of the Earth, and its diameter is 4,352 miles, against the 7,918 miles of the Earth. The area of the planet's surface is rather more than a quarter of our world's.

A Long Path Round the Sun

Mars circles round the Sun in an orbit whose diameter is half as large again as that of the Earth, and at its greatest distance from the Sun the planet is 154,860,000 miles away, while at its nearest it is only 128,440,000 miles from the Sun.

Being farther away, Mars does not receive anything like so much light and heat from the Sun as does the Earth. In fact, the amount it receives is less than a half of that which reaches the Earth.

It must be remembered that as the distance of Mars from the Earth varies so greatly at different periods, its size also varies. When it is nearest it appears as a body with about seven times the diameter that it exhibits when it is farthest away. The diagram on the next page shows how much its size as seen from the Earth varies at different periods.

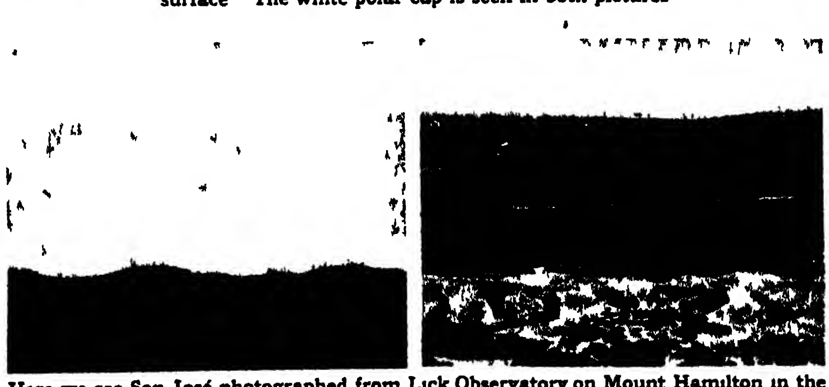
The brightness also differs a great deal, for when it is most remote it is hardly as bright as the Pole Star, but when it is nearest it is fifty times brighter, and rivals Jupiter in brilliance.

Mars has its axis inclined at almost the same degree as the Earth, and it turns on its axis in 24 hours 37 minutes 22.7 seconds. Its day, therefore, is almost the same length as the Earth's day. It is interesting to remember that Mars is the only heavenly body besides the Earth and the Moon whose exact period of rotation is known, for the Sun and the other planets have gaseous or cloudy surfaces, so that there are no fixed points by which the rotation can be calculated.

To complete its journey round the Sun Mars takes 687 of our days, that is, its year is nearly twice as long as ours.

Until the last quarter of the nineteenth century Mars was regarded as having no moons attending it, but in 1877 two small moons were found. It is not surprising that they were not discovered before, for they give us only about as much light

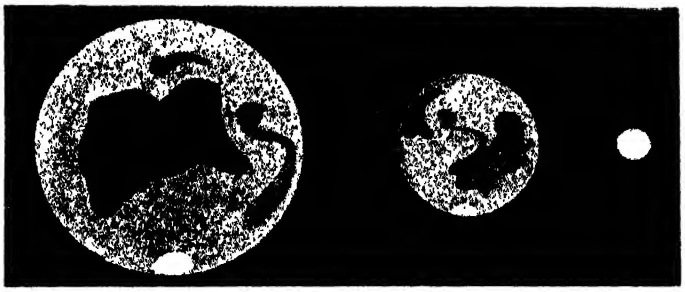
The planet Mars photographed at Lick Observatory, California. The photograph on the left was taken by means of violet rays, and that on the right by infra-red rays. It will be seen that the right-hand picture shows distinct markings on the planet's surface. The white polar cap is seen in both pictures



Here we see San José photographed from Lick Observatory on Mount Hamilton in the same way as the pictures of Mars above were taken. The photograph on the left was taken by means of violet rays, and that on the right by infra-red rays. As in the case of Mars, one photograph shows much more detail than the other. San José is thirteen miles from the observatory

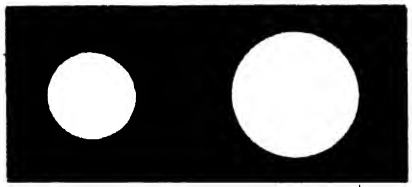
as the reflection from a man's hand would do at a distance of a hundred miles.

These moons are very small indeed. It is estimated that one of them, which is called Deimos, is only about ten miles in diameter, or as far across London in a straight line as from Hammersmith to Poplar. The other moon, called Phobos, is about twenty miles in diameter, or perhaps large enough to eclipse the Sun totally for any Martians that there may be, for this Moon is very near its planet.



The relative sizes of Mars, as seen through a powerful telescope from the Earth. On the left it is at its nearest, in the centre at its mean distance and on the right at its farthest from our globe

The most remarkable thing about these moons, however, is not their small size, but their nearness to the planet. Phobos circles round Mars at a distance of 4,000 miles, and it completes its journey in 7 hours 39 minutes, less than one-third of the time that Mars itself takes to turn on its axis. The strange result is that to an inhabitant of Mars, Phobos would appear to rise in the west and set in the east, making two revolutions round the planet every day.



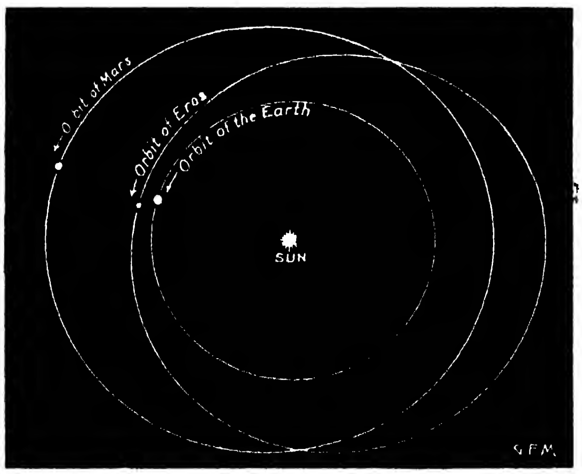
The comparative sizes of the Sun as it appears, on the left, from Mars and, on the right, from the Earth

Deimos, which is 12,000 miles from the surface of Mars, remains above the Martian horizon for 60 hours at a time, and passes through all its phases twice between rising and setting. Then it remains below the horizon for three whole days

A Beautiful Appearance

Mars is slightly flattened at its poles, rather more so, in fact, than the Earth.

Seen through a telescope Mars presents a very beautiful appearance with great diversity of colour on its surface. There are large orange-coloured regions which give the ruddy tinge to the planet, when viewed with the naked eye. These regions are believed by astronomers to be deserts, for it is considered that the Sahara seen from another world through a telescope would have very much the same appearance.



The orbits of the Earth, Mars and the minor planet Eros, showing how the two latter cross one another. It will be seen from the diagram that these orbits are not concentric

Then there are large bluish-green regions that used to be regarded as seas, and were given the names of seas on Martian maps. They are, however, now believed to be the dry beds of ancient seas, and the colour is thought to be due to some form of vegetation. It is believed by scientists that if these were great bodies of water the planet's atmosphere would be much more cloudy than it is.

These regions, too, are not always of the same colour. At certain seasons they take on a brownish tint, and it is then that certain stripes and lines are seen crossing them. Further, no reflected image of the Sun is ever noticed in these areas, which would probably be the case if they really consisted of seas.

Another feature of the Martian landscape is the large white spots which are seen round each pole, and which get less and greater at different seasons. Mars must have very much the same seasons as the Earth, and it is during the Martian summer in the northern hemisphere of the planet that the north polar cap almost disappears, and in the summer season of the southern hemisphere that the south polar cap wanes.

In the winter season in each hemisphere the white caps reach their maximum of size. It is, therefore, a natural explanation that these caps must be masses of frozen material, probably water, and possibly carbon-dioxide.

One of the arguments used against the possibility of life on Mars is that the planet is too cold to support life, for Mars receives only about four-ninths as much heat from the Sun as does the Earth.

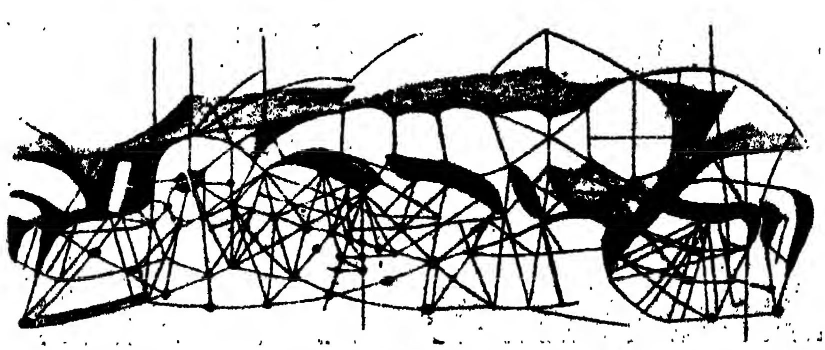
The Mysterious Canals

Now we come to the most interesting of all the markings detected on the surface of Mars, which are the so-called canals. Some astronomers are unable to see them, and photographs give little help. But a number of very distinguished astronomers have made careful maps of the planet showing a regular series of straight lines.

As these appear more distinct when the polar caps disappear, it has been supposed that they are channels which fill with water, and that what we see is not the water-courses themselves, but a wide band of vegetation due to irrigation,

Professor Lowell and others have thought from the fact that the "canals" are so straight that they were made by intelligent beings.

The only thing we can do is to wait for further information.



A map of part of the surface of the planet Mars, drawn by the late Professor Percival Lowell, who made a close study of this planet, and believed that the lines were canals made by intelligent beings, and the dark spots at their intersections oases. Other astronomers have suggested that they were wholly or in part optical illusions, but scientific opinion now agrees that they have some existence They grow more distinct when the polar caps diminish, and it is thought that this is due to vegetation

A SIXTEENTH CENTURY MIRACLE

It is doubtful if in the annals of any nation or any time there can be found another man so remarkable as William Shakespeare, of Stratford-on-Avon. Born in a quiet little country town, he became the man for all time. As we read his works we feel he knew everything, and it is not only Englishmen who think like this; the Germans also speak of "Our Shakespeare," and have written more books about him than are to be found in English. Why is it that Shakespeare can never die, but, "crowned with laurel, live eternally"? An attempt at an explanation is given in these pages

THE word "miracle" is from a Latin word meaning "to wonder," and it is therefore something which excites our wonder and astonishment. Generally the word is used for something so extraordinary that it is regarded as being due to some departure from the known laws of Nature, that is, a supernatural event.

Of course there are many people who say they do not believe in the possibility of a miracle, but let them consider something which happened in the sixteenth century and then see if they are still of the same opinion.

It was an occurrence so amazing that no one can explain it, and yet as in the case of other miracles, all sorts of attempted explanations have been given which are quite as foolish as the suggestion, for instance, that the fall of the walls of Jericho was due to the atmospheric vibrations set up by the blowing of the Israelite trumpets.

On or about April 23rd, 1564, there was born in Stratford-on-Avon, then a town of 2,000 inhabitants off the main routes of traffic, a boy of whose childhood nothing particular is recorded. His father was a well-known citizen of Stratford named John Shakysper, or Shakespeare, for in those days you spelt your name in any way you liked, and one man would spell his own name in half a dozen ways or more.

John had been brought up on a farm at Snitterfield, a little village four miles from the town, and when his father died the farm was carried on by another son, Henry. John therefore went into Stratford to seek his fortune as a townsman, and he seems to have been very successful. He set up as a trader dealing in all kinds of agricultural produce.

In those days businesses were not so specialised as they are to-day, and there is nothing curious in the fact that John Shakespeare was a butcher, a wool merchant, a corn merchant, a dealer in skins and leather, and a maker of gloves. When he killed the sheep from his brother's farm and other places round about he would sell the meat and the wool, and then he would tan the skins and make some of them up into gloves.

A place like Stratford in the sixteenth century was very self-contained. Roads in England were not good, and there was little communication between district and district, so that a local community had to do everything for itself.

John Shakespeare made what would be regarded as a very successful marriage. His wife, Mary Arden, was the youngest of seven daughters of a well-to-do yeoman, and when, a few months before the wedding, her father died, he left her an estate of 54 acres, with a house and two cottages. The place was called Asbies, and Mary received also a sum of £6 13s 4d in money, a substantial amount for those days. She was something of an heiress

Young William Shakespeare, accused of poaching, is brought before Sir Thomas Lucy at Charlecote Hall. From the well-known painting by Thomas Brooks

John thrived in business and seems to have been respected by his fellow townsmen for they elected him a member of the Corporation and a year or two afterwards made him Chamberlain of the borough Still later he became an alderman and was afterwards chosen High Bailiff of the borough an office corresponding to that of Mayor In the record he is described as Mr John Shakyspere ' Indeed in the ten years following his marriage he occupied almost every office of dignity in the borough

The boy that was born in April 1564 was baptized in Stratford church on the 26th of that month and was given the name of William The entry appears in the register in Latin William son of John Shakspere — still another spelling of the surname Three more sons and two more daughters were born to John and Mary Shakespeare

How little the people of Stratford realised what an extraordinary man the boy William was to grow into! He was just like any other boy full of fun and mischief playing all sorts of games like football hide and seek prisoner's base and nine men's morris a game that can be played indoors on a board like draughts or chess or out of doors on the ground with pegs or stones It must have been a great nuisance to William Shakespeare and his boy friends when the holes in the ground were filled up with mud and they could not play their game of nine men's morris

He went to school at the free Grammar School in Stratford like all boys of his class but he can hardly have learnt a great deal as he left when he was thirteen Apparently school life often proved drudgery for he speaks in later years of "schoolboys' tears" of "school days frightful desperate wild and furious" of the readiness with which schoolboys turn from their books and of "the whining schoolboy with his satchel and shining morning face creeping like snail unwillingly to school"

Then while no doubt he made many good friends at school for he speaks of 'school days friendship' yet there were evidently some fellow-scholars whom he found anything but friends for he refers to "my two school fellows whom I will trust as I will adders fanged"

Those were days in which school was very different from what it is now There were few holidays little attractiveness about the lessons, and small sympathy between schoolmaster and scholar Of a small boy he writes "he had rather see the swords and hear a drum than look upon his schoolmaster"

Shakespeare Remembers His Schooldays

Perhaps then when he had to leave school at thirteen because his father was no longer prosperous and was indeed struggling with financial difficulties he may have been very glad The teaching of boys was confined almost entirely to the Latin language and literature and very dull it was

In some of the old Grammar Schools a smattering of Greek was also taught and it is more than likely that this was the case at Stratford Grammar School for William Shakespeare's friend Ben Jonson who was himself a scholar credits him with "small Latin and less Greek" though an early biographer tells us that "he understood Latin pretty well"

The house where Shakespeare was born at Stratford-on-Avon

Whatever he learnt and saw in those early days there is one thing quite certain that William Shakespeare remembered them He was only eleven years old when Queen Elizabeth made a progress through Warwickshire on a visit to Kenilworth the castle of her favourite, the Earl of Leicester

Queen Elizabeth at Kenilworth

During her stay the Queen was entertained to a whole round of masques and pageants in Kenilworth Park and as this was only fifteen miles from Stratford, it is more than likely that young Shakespeare went thither with his father, the distinguished citizen of Stratford and in one of the plays which he afterwards wrote he describes some fantastic scenes which were probably among those he saw

What William did immediately after he left school we do not know with any certainty Some say that he helped his father in the butchering business, and was apprenticed to that trade His earliest biographer tells us that "when he killed a calf he would do it in a high style and make a speech" Others think he fought as a soldier in the Low Countries, and others that he may have entered a lawyer's office

Whatever he may have done for a living one thing is certain he had grown up "a handsome well shaped man very good company and of a very ready and pleasant smooth wit"

He was less than nineteen years old when he married Anne Hathaway a woman eight years older than himself It could hardly be called a prudent marriage and there is no record of it in the local registers All we know is that consent was given for the marriage to proceed with only one calling of the banns

A daughter was born and baptised in the name of Susanna and two years later there were twins a son who was named Hamnet after a friend of the family and a daughter Judith

To a high spirited young man skilful at archery and sports it must have been a great temptation to go poaching and this is what William Shakespeare did He is said to have joined in a midnight poaching expedition to capture some deer in the grounds of Charlecote Manor about four miles from Stratford —not the first prank of the kind that he had engaged in He was caught in the act and was kept a prisoner till the morning, when he was brought before the lord of Charlecote Sir Thomas Lucy

What punishment was meted out we do not know although one account says that he was whipped, as he had been whipped before for poaching and that he was also imprisoned In any case Shakespeare is said to have become very indignant at his treatment In order to get his revenge he wrote a ballad about Sir Thomas Lucy, with punning jokes on his name This he took one night and fixed to the park gates The knight was furious, and seems to have made things so hot for William Shakespeare that the young man was compelled to leave his native home

London then, as in Dick Whittington's time, was the goal of all youths who hoped to make their fortune and what youth did not? Shakespeare

was no exception, and he made up his mind to seek his fortune in the capital then a walled city of narrow streets, open sewers and wooden houses, with only 200,000 inhabitants. But whether he went direct, or first of all obtained some employment in another part of Warwickshire, we do not know. It has been said that for a time he acted as a schoolmaster.

However with little or nothing in his pocket he finally made his way to London, most likely going by way of Oxford and High Wycombe.

There is little doubt that from boyhood young Shakespeare had had a hankering after the theatre. He wanted to be an actor although at that time actors unless they obtained a licence from a peer of the realm, or some personage of even higher degree' which means a prince or a sovereign were regarded as rogues and vagabonds and were liable to be treated roughly as beggars.

As a preliminary young Shakespeare found out where London's two theatres were situated and began to attend at one of them earning a few honest coppers by looking after the horses of people who rode to the play.

A Call for Shakespeare

This was the custom of the day and Shakespeare is said to have done his work so well that playgoers when they arrived and were no doubt beset with urchins and youths wanting to hold their horses used to call out for Will Shakespeare. After a time he worked up quite a business, employing other youths to act under him. His job was very much like that of the men who today look after motorcars at parking places in London and other cities and towns.

The theatre to which he attached himself was probably that known as The Theatre in Finsbury Fields. The only other London theatre was close by in Moorfields, and was known as The Curtain, a name which has survived in that of a road in the district still called Curtain Road.

After a time young Shakespeare was offered a job inside the theatre as callboy or prompter's assistant, to warn the actors when it was their turn to go on the stage, and soon afterwards he became an actor. He joined a company that worked under the patronage of the Earl of Leicester which was then performing at The Curtain in Shoreditch. This like the other theatre in Finsbury Fields was outside the city walls.

Shakespeare, as a youth in London, takes charge of the horses of citizens visiting the theatre in Finsbury Fields

The company to which Shakespeare was attached soon migrated to more suitable quarters for in 1592 they opened a third London theatre called The Rose, at Bankside Southwark, on the other side of the Thames. It was here that his earliest successes were achieved.

Then the theatre in Finsbury Fields was pulled down and partly with its materials a new theatre was erected at Bankside which became famous as The Globe. It was octagonal in shape, and was built of wood, and it is almost certainly this theatre which Shakespeare describes in one of his plays as "this wooden O"

Shakespeare now well known in the theatrical profession, had a share in the profits of The Globe, and from the year 1599 it was the only playhouse with which he was professionally connected till near the close of his acting days, when he occupied the Blackfriars Theatre, which was a transformed dwelling-house.

During the time he stayed in London Shakespeare lived quite near to the theatres in which he was acting. He lodged for most of the time near the Bear Garden in Southwark.

But Shakespeare did not remain in London all the time. For in Queen Elizabeth's days actors (there were no actresses for the female parts were taken by boys and young men) used to tour the Provinces just as they do now and perhaps even more regularly. It was in the summer that they left the capital and all country towns as large as Stratford could be sure of receiving a visit from a company of travelling actors at least once in the year.

The company to which Shakespeare was attached played at different times in Barnstaple Bath Bristol, Coventry Dover Faversham Folkestone Hythe, Leicester Maidstone Marlborough New Romney Oxford Rye, Saffron Walden and Shrewsbury. All these towns may be pretty certain that Shakespeare acted in them at some time between 1594 and 1614. Some have even thought that Shakespeare visited Scotland but this is by no means certain. He played before Queen Elizabeth more than once.

The First Plays

But Shakespeare was not content to be merely an actor. He wanted to be a dramatist and write the plays which the actors performed and it was not very long before he began doing so.

It is not certain which was his first play. Probably he touched up somebody else's play, for it was the custom in his day for professional playwrights to sell their plays outright to an acting company, and they had no rights in them afterwards. The manuscript would be revised, and both added to and cut by other hands than the author's before it was produced.

Shakespeare no doubt gained his early experience as a dramatist by revising other men's plays. Sometimes his alterations would be slight, and at other times he would do a great deal of re writing.

At last, in 1591, he produced a play of his own. He called it "Love's Labour's Lost" and did what he scarcely ever did afterwards, made up the plot instead of borrowing it from somebody else. It was described as "a pleasant conceited comedie," and although the scene was laid in Navarre, and the names of the chief characters were drawn

from the leaders in the Civil War in France, the play was really a description of life and manners in London and the English countryside.

The next year Shakespeare wrote another play, "The Comedy of Errors," and about the same time "A Midsummer-Night's Dream." Then came the first of the plays dealing with English history, "Henry VI," and afterwards "Richard II" and others.

He next began a series of tragedies, the first being "Romeo and Juliet," produced at the Curtain Theatre in 1596. This was followed by "Hamlet," "King Lear," "Othello," "Macbeth," and others, and it was in the tragedies that the dramatist reached his most sublime heights, both in the delineation of character and in the masterly use of the English language.

Almost directly he began writing plays he roused the jealousy of rival authors, and one of these, Robert Greene, prepared a pamphlet called "Greene's Groatsworth of Witte bought with a Million of Repentaunce"

A Rival

The pamphlet was not published, but it has survived, and we can read what Robert Greene thought of William Shakespeare and his practice of borrowing plots from other people, for there is no doubt to whom the author is alluding when he refers to "those puppits I meane that speake from our mouths, those anticks garnisht in our colours." He goes on. "Trust them not, for there is an upstart crow, beautified with our feathers, that with his Tygers heart and wrapt in a Players hide, supposes he is as well able to bumbast out a blanke verse as the best of you, and being an absolute Johannes Factotum, is in his owne conceit the only Shake-scene in a countrie."

It is all rather feeble, but Greene's reference to his rival as both a player and an author makes it clear that he thought every cobbler should stick to his last and an actor remain an actor, leaving the writing of plays to others.

Shakespeare's plays, which were in blank verse, like most plays of the day, became very popular and were highly successful. They were played before the Queen and other distinguished spectators, and from these and his acting he made a substantial income, over £1,000 a year according to our present values.

Then he returned to his birthplace, bought the largest house in the town known as New Place, put it into thorough repair, planted an orchard, and in the garden planted with his own hands a mulberry tree, which was only cut down in 1758.

This tree's end is one of the most astounding examples of vandalism to be found in English literary history. Shakespeare's old home had been bought by a wretched man, a clergyman, who cared nothing for Shakespeare. People interested in the poet used to look over the garden wall at the mulberry tree, and to save himself from what he regarded as a nuisance, the Reverend Francis Gastrell, the gentleman in question, cut down the tree. Dante Gabriel Rossetti has written a poem to commemorate the sacrilege, and it is worth quoting here:

Shakespeare reading Hamlet to his family. From an old painting

This tree, here fall'n, no common birth or death
  Shared with its kind. The world's enfranchised son,
  Who found the trees of Life and Knowledge one,
Here set it, frailer than his laurel-wreath
Shall not the wretch whose hand it fell beneath
  Rank also singly the supreme unhung?
  Lo! Sheppard, Turpin, pleading with black tongue
This viler thief's unsuffocated breath!
We'll search thy glossary, Shakespeare! whence almost,
  And whence alone, some name shall be reveal'd
  For this deaf drudge, to whom no length of ears
  Sufficed to catch the music of the spheres;
  Whose soul is carrion now--too mean to yield
Some Starveling's ninth allotment of a ghost.

The dramatist continued to prosper, his income increased, he had a financial interest in more than one London theatre, and he spent his time between London and Stratford. He helped his father in his financial difficulties, and obtained for him a coat of arms from the College of Heralds, which showed a spear, in punning allusion to the family name.

He also helped his younger brother Edmond, who had come to London as an actor, and who lies buried in Southwark Cathedral, on the south side of the Thames. In the parochial monthly accounts there is an entry: "1607, December 31st. Edmund Shakespeare, a player, buried in ye Church with a forenoone knell of the great bell, 20s." William is believed to have defrayed the funeral expenses. A portrait of Edmond Shakespeare is to be seen in a memorial window in the cathedral, together with the figures of Shakespeare and Edmund Spenser.

Shakespeare's son Hamnet died when he was twelve, but both his daughters married and survived their father, the elder, Susanna, inheriting his house and estate, while to the younger, Judith, he left other property and money. He also made some provision for his surviving brothers and sisters, but his mother died a few years before he did. His wife survived him seven years.

The Portrait Bust

William Shakespeare died on April 23rd, 1616, and was buried in the chancel of Stratford Church, where a few years later a portrait bust sculptured by a Dutchman was erected, and is still to be seen. We are not sure what the dramatist looked like, for the bust is very rough, and the features in the few alleged portraits that have come down to us vary greatly in appearance.

Shakespeare's daughter Judith had three sons, but they left no family, and Susanna's only child Elizabeth, who died in 1669, was the poet's last descendant.

Now there seems nothing very miraculous or even romantic about all this. It reads like the ordinary life of an ordinary man, and we may well ask what it is in Shakespeare that should cause him to be regarded as a miracle or even as an outstanding character in history. Men of many nations are agreed that he is unique and that there has never been another man like him in any land or in any age. Why?

Well, it is his plays, of which about thirty-seven have come down to us, that pick him out from all other writers, and indeed from all other men of whom we have any record. In these plays he portrays every possible kind of character of which human nature is capable.

Some are men and women of lofty ideals and of lion-like courage, while others are among the basest and the most treacherous of mankind. Some are brimming over with fun and good humour, while others are in the depths of despair. Some are frivolous, and unreliable, while others are of sterling worth and true as steel.

In portraying these characters Shakespeare often scales the loftiest heights and plumbs the darkest depths, and all this he does in such magnificent, virile English as to impress the words upon all who hear or read them. There is no kind of passion, or ambition, or virtue, or duty, or nobleness, or evil, or weakness, or baseness, or courage, or daring, or fortitude, or prowess, or heroism, or chivalry, that is not found described in Shakespeare's plays more realistically and splendidly than it has ever been described before or since.

No matter what emotion stirs us, whether of pleasure or of pain, even if we are unable to put our own feelings into words, we can find in Shakespeare's plays an exact expression of our thoughts. In Shakespeare it is as though all humanity had been concentrated into one man, and this is the miracle that staggers the world.

How could one man know the whole of human experience? How could he portray in living words every thought and feeling of which humanity is capable? How could he in a few years acquire such vast knowledge of life in all its activities, with the technical details of trades and professions which we find in his plays?

His references to law are so accurate that a book has been written to show that Shakespeare must have been a lawyer by profession. His soldiering terms and descriptions of camps and battles have made other men think he must have been a soldier. In music it is the same, and essays have been written to show that he was a professional musician. From references in his plays men at different times have come to the conclusion that he must have been things so different as a schoolmaster and a butcher. From his theological references they have claimed him as a true Protestant and as a true Catholic. In sports like falconry and hunting he shows the knowledge of an expert. Of flowers and birds and insects and Nature generally, including astronomy, he writes like one who had given his whole life to their study.

Take, for example, astronomy. How well he knew the heavens and the science of the sky as understood in his day! He tells of sunrise:

> The morning from whose silver breast
> The sun ariseth in his majesty,
> Who doth the world so gloriously behold
> That cedar tops and hills seem burnished gold.

Then comes evening, when "the sun sets weeping in the lowly west," and soon "the skies are painted with unnumber'd sparks," and the moon appears, "that tips with silver all these fruit-tree tops."

Shakespeare notes the phases of the moon:

> O swear not by the moon, the inconstant moon,
> That monthly changes in her circled orb.

Sometimes moon and sun are eclipsed: "Methinks it should be now a huge eclipse of sun and moon."

Shakespeare with a number of his friends. From the painting by Faed

He bids us "Look how the floor of heaven is thick inlaid with patines of bright gold," and seems to know the nature of the stars when he exclaims, "Doubt thou the stars are fire, doubt that the sun doth move!"

Then he notices the meteors. "I see thy glory like a shooting star fall to the base earth from the firmament." Occasionally the meteors come in showers: "the vaulty top of heaven figured quite o'er with burning meteors." He knows of comets, though these are rare—"some comet or unusual prodigy." He has noticed the stationary Pole star:

> I am constant as the northern star,
> Of whose true fixed and resting quality
> There is no fellow in the firmament.

He mentions Mars 36 times, Jupiter 30 times, Venus 21 times, Mercury 15 times, and Saturn 5 times.

He was a close student of the weather, he knew a great deal about doctoring, and lunacy, and the human frame, and dietary, and the value of sleep, and the evils of superstition. He was full of wit and humour, and was always poking fun at the weaknesses of his fellow men. Hypocrisy he loathed.

But the marvel is that with all his profound knowledge and philosophy, Shakespeare could clothe his thoughts in language that not only pleases the most fastidious literary taste, but can be understood and appreciated by the simplest and most ignorant of people.

The charwoman, when kept waiting, quotes Shakespeare, although she does not know it, when she describes herself as "patience on a monument," or when she speaks of another lady as "past all shame." She will tell you that "care killed a cat," that "men were deceivers ever," and in speaking of her family she always says "we have seen better days"; while referring to her present work she bemoans "that it should come to this!" She may tell you of a relation who has "eaten me out of house and home," and will have you understand that it is "neither here nor there."

Every one of us, every day, is using some telling phrase that Shakespeare invented: "the short and the long of it," "as good luck would have it," "laid on with a trowel," "neither rhyme nor reason," "give the devil his due," "I know a trick worth two of that," "off with his head!" "alone I did it," "the weakest goes to the wall," "the very pink of courtesy," "can such things be?" "I bear a charmed life," "more in sorrow than in anger," "to be or not to be, that is the question," "ay, there's the rub," "suit the action to the word," "to the manner born," "more honoured in the breach than the observance," "more sinn'd against than sinning," "every inch a king," "single blessedness," "the green-eyed monster," "let slip the dogs of war," "trifles light as air," "the seamy side," "not wisely, but too well," "the course of true love never did run smooth," "what's in a name?" "hoist with his own petard," "as merry as the day is long"—these are only some of the thousands of phrases that Shakespeare has made part of the English language.

He wrote in the language that Tyndale had fixed for ever when he translated the New Testament, but he enriched the language with hundreds of new words, which he coined or first placed on record. Abstemious, critic, dauntless, fretful, gloomy, headsman, inlaid, jaunt, mimic, rascally, savagery,

squabble, swaggering, unearthly, unreal—these are a few of the words we find first in Shakespeare

But it was in the invention of compound words that he was so fertile Such words were rare in English till he began to multiply them Here are a few specimens from his plays blood-stained, chimney-top, cold-blooded, dark-eyed, ear-piercing, even-handed, eye-glass, foot-fall, fortune-teller, health-giving, ill-starred, lady-bird, love-affair, mountain-top, pale-faced, rat-catcher, school-boy, school-days, short-

Shakespeare reading one of his plays before Queen Elizabeth From the painting by Ender

lived, tear-stained, tempest-tossed, water-colours

Altogether Shakespeare used about 15,000 different words in his plays and poems, whereas Milton used only 6,000 and the Old Testament contains but a similar number

Modern authors go to Shakespeare for titles for their books In little more than a year nearly forty books had titles taken from his works among them "Journey's End," "All Our Yesterdays," "Brief Candles," "Cakes and Ale," "Merely Players," "Her Privates We," "Full Fathom Five" and "Salad Days"

It is astonishing how we can find in Shakespeare's works quotations that seem to fit admirably events and inventions that are later than his day "I'll put a girdle round about the earth in forty minutes" is an excellent description of telegraphy or wireless, while the broadcasting of music is well expressed in the words

> And those musicians that shall play to you
> Hang in the air a thousand leagues from hence

So wonderful and apparently impossible is the miracle of the boy from Stratford that attempts have been made again and again to prove that his plays were written by someone else, by a scholar and man of the world like Francis Bacon for example

Without going into any arguments for or against such theories it is sufficient to say that none of the keen literary men who knew William Shakespeare so well and spent so much of their time with him had any doubt that he was the author of the plays He was as much a wonder to them as to us and they did not hesitate to say so They refer to him as the 'Star of Poets,' the 'Poets' King,' and such titles they give to no one else Ben Jonson shows what he thinks in the lines

> While I confess thy writings to be such
> As neither Man nor Muse can praise too much

and he tells us very truly that "He was not of an age, but for all time" Another contemporary author and friend Leonard Digges, says

> Be sure our Shakespeare, thou canst never die,
> But, crowned with laurel, live eternally

There is only one book greater than Shakespeare and that is the Bible But the Bible is really a collection of books written by many men in many lands and many ages It is in the Bible and Shakespeare that all human life is summed up, and we who speak the English language may be thankful that we have these stupendous works in our own tongue

In what was probably his last play, "The Tempest," Prospero undoubtedly was regarded as resembling the poet himself, and it is interesting to remember this when reading the parting words of Prospero

> You do look, my son, in a mov'd sort
> As if you were dismay'd Be cheerful, sir,
> Our revels now are ended These our actors
> As I foretold you, were all spirits and
> Are melted into air, into thin air
> And like the baseless fabric of this vision,
> The cloud-capt towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherit, shall dissolve,
> And like this insubstantial pageant faded
> Leave not a rack behind we are such stuff
> As dreams are made on, and our little life
> Is rounded with a sleep

As Professor Walter Raleigh says "In all the work of Shakespeare there is nothing more like himself than those quiet words of parting —'Be cheerful, sir, our revels now are ended' Yet they are not ended, and the generations who have come after him, and have read his book, and have loved him with an inalterable personal affection, must each, as they pass the way that he went, pay him their tribute of praise.

THE GREAT MARVEL OF THE BUSY BEE

The story of the bee and its remarkable communal life is one of the greatest romances of natural history. The bee itself is a wonderful creature, specially adapted to the needs of its life, and in these pages we read a great deal about the bee. In other parts of this book the story of what goes on in the hive is told in detail.

All living creatures are adapted to the circumstances in which they have to live, and are fitted for the work which they have to do. Men of science tell us that this adaptation has been brought about by nature over a course of millions of years, and the process by which the various creatures have reached their present form and development is known by scientists as evolution.

We read something about the processes of evolution in other parts of this book, but the adaptation of the living creature to its needs and circumstances is nowhere better seen than in that familiar insect the honey bee. Its extraordinary and romantic life in communities organised for work is told elsewhere, but here we see something of the bee itself.

There are three kinds of bee: the so-called queen, who is really the mother of the community, the drones, who are male bees, and the workers of various kinds who, like the queen, are females. All the bees except the drones are busy labourers and almost kill themselves with work.

The queen spends much of her time laying eggs, but the drones live a life of luxury. They are often fed by the workers, and spend most of their time either eating or sunning themselves. But when winter approaches the drones are killed off by worker bees specially appointed for the task. The drones have no sting, and when they go in and out of the hive they push the other bees about in what seems a very rude way.

Many beekeepers have been puzzled by the curious dance-like flight of their worker bees at certain times of the day. Professor Karl von Frisch, an Austrian entomologist, believes that the dances are the bees' way of telling each other where plenty of food is to be found.

When bees fly in circles, clockwise and anti-clockwise alternately, it means there is a clump of pollen-laden flowers within a distance of 150 or 300 feet of the hive. If the feeding place is more than 300 feet from the hive the bees returning with the news perform a sort of wagtail dance; turning rapidly on their own axis in a half-circle, returning to their first position, making a half-circle in the other direction, and then returning to their original position.

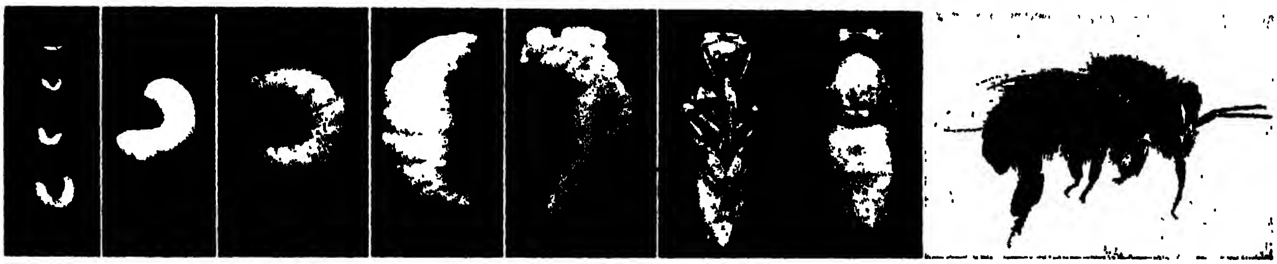
Even more remarkable is the bees' method of indicating the direction of the feeding ground they have discovered; often some distance away.

Professor Frisch thinks that if the feeding place lies in a direct line between the sun and the hive, the bees perform the wagtail dance in a position vertical to the base of the hive. When the hive is on a direct line between the sun and the feeding place, the bees dance head downwards.

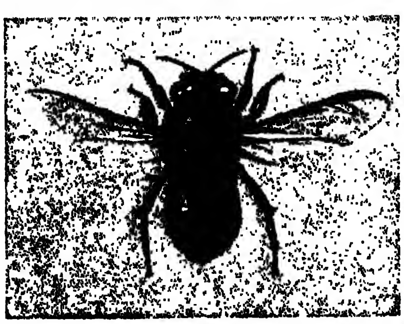
If the feeding place lies to the left or right of a direct line between the sun and the hive, the bee orientates its dance accordingly. On every occasion when Professor Frisch observed these dancing flights, at the end of the performance a number of bees immediately followed the dancer in flying off in the direction indicated.

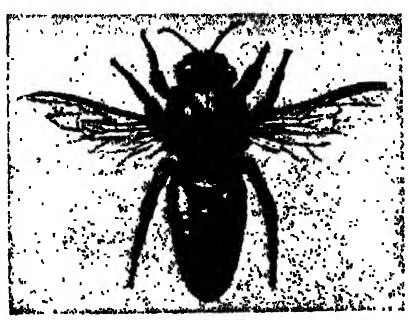
A bee has five eyes, one situated on each side of the head and three on top. The three top eyes are single, but those at the sides are compound, that is, they have many facets or faces so that these eyes are almost like a collection of smaller eyes. In the worker's compound eye there are over 6,000 facets, no two pointing in exactly the same direction. The drones, however, have 13,000 facets in each compound eye, while the queen has only 5,000.

What is the use of the compound eye? Why should there be so many facets? It used to be thought by men of science that each facet gave a separate image of any object which it faced, so that the bee saw many thousands of these objects all nearly alike



Here we see the various stages in the history and development of the bee, from the egg and the newly-hatched grub, to the growing larva, the pupa, and finally to the perfect winged insect with its long tongue. The change of form as larva turns to pupa can be seen.





These three photographs show the three kinds of bee, somewhat magnified. On the left is a worker, in the middle a queen, and on the right a drone. The worker and the queen are females, while the drone is a male bee.

Such a power however seemed quite useless and now scientists have changed their minds and think that each facet gives a picture only of that part of an object which is immediately in front of it and then that the brain of the bee combines these together to form a single image. This is much more likely than that there should be thousands of images seen at one time of the same object. The single eyes are believed to be used for looking at objects which are very close, while the compound eyes see things that are farther off.

Then standing out from the head are two feelers known as antennae. These are very wonderful organs for they are used for smelling and the ears of the bee are placed in them. They enable the insect to find its way about and to communicate with other bees. The antennae are jointed. The longer joints are covered by long fine hairs, while the smaller joints also have hairs which are shorter and thicker than the others.

A swarm of honey bees on a creeper-clad fence

On each antenna a worker has about 14 000 hairs each being linked up with a nerve, and it is these hairs which enable the bee to go about and do things in the dark. They are very sensitive, and the least touch on the hair is at once communicated to a nerve centre. In this they are very much like the whiskers of a cat.

On each antenna there are more than 2,400 holes; the queen has fewer, but the drone has a much larger number namely 37,000. Each hole is really a little nostril.

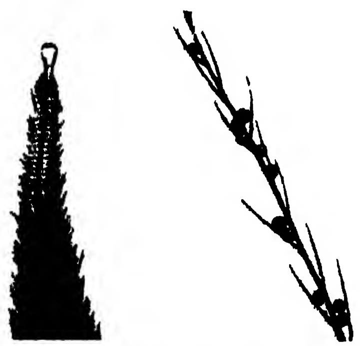
Then the bee has a pointed tongue or trunk, and in the case of the worker there are about a hundred rows of hairs though fewer of these are found on the queen and the drone. It is by means of the hairy tongue that the bee collects nectar from the flowers. It thrusts its tongue out and the nectar sticks to the hairs in minute droplets.

A bee also possesses powerful jaws, and when the insect visits a flower so long that its tongue will not reach to the nectar it cuts a hole with its jaws and inserts its tongue through the hole. It can even cut its way out of a cardboard box.

The body of the bee is covered with hairs with tiny spikes on them, and when the bee goes into a flower the pollen is caught by the hairs and is then carried away. When another flower is visited the pollen is rubbed off, and if that flower is a female blossom it is fertilised so as to produce seed. The legs of the bee which, as in the case of all insects are six in number divided into three pairs are used as hands as well as feet. It is said that the bee can raise and lower each foot 1,200 times a minute.

Then the bee has a wonderful arrangement of wings. There are four and this division enables the wings to be packed away, when they are not wanted much more tightly than if there were only two. But for flying two wings are much better than four so the bee has a number of hooks which enables each pair of wings to be fastened together so that in effect they become really a single pair while the flight is going on.

There are other wonderful things about the bee's body. On the third pair of legs there is a kind of basket in which pollen is carried from the flowers to the hive. Then there are

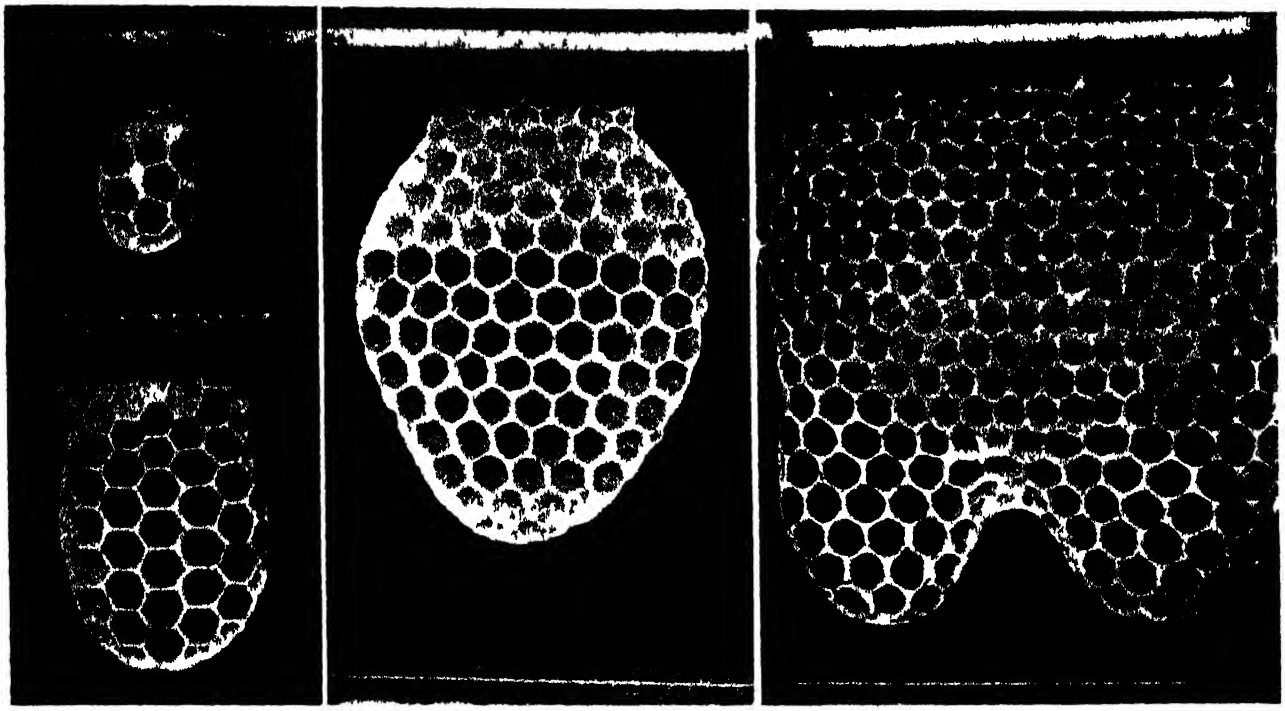


On the left is shown the tip of a bee's tongue, with the minute "spoon" by means of which it collects the nectar from the flowers. On the right is seen a hair of the bee, with pollen grains which have been caught during a visit to a flower. Both are greatly magnified

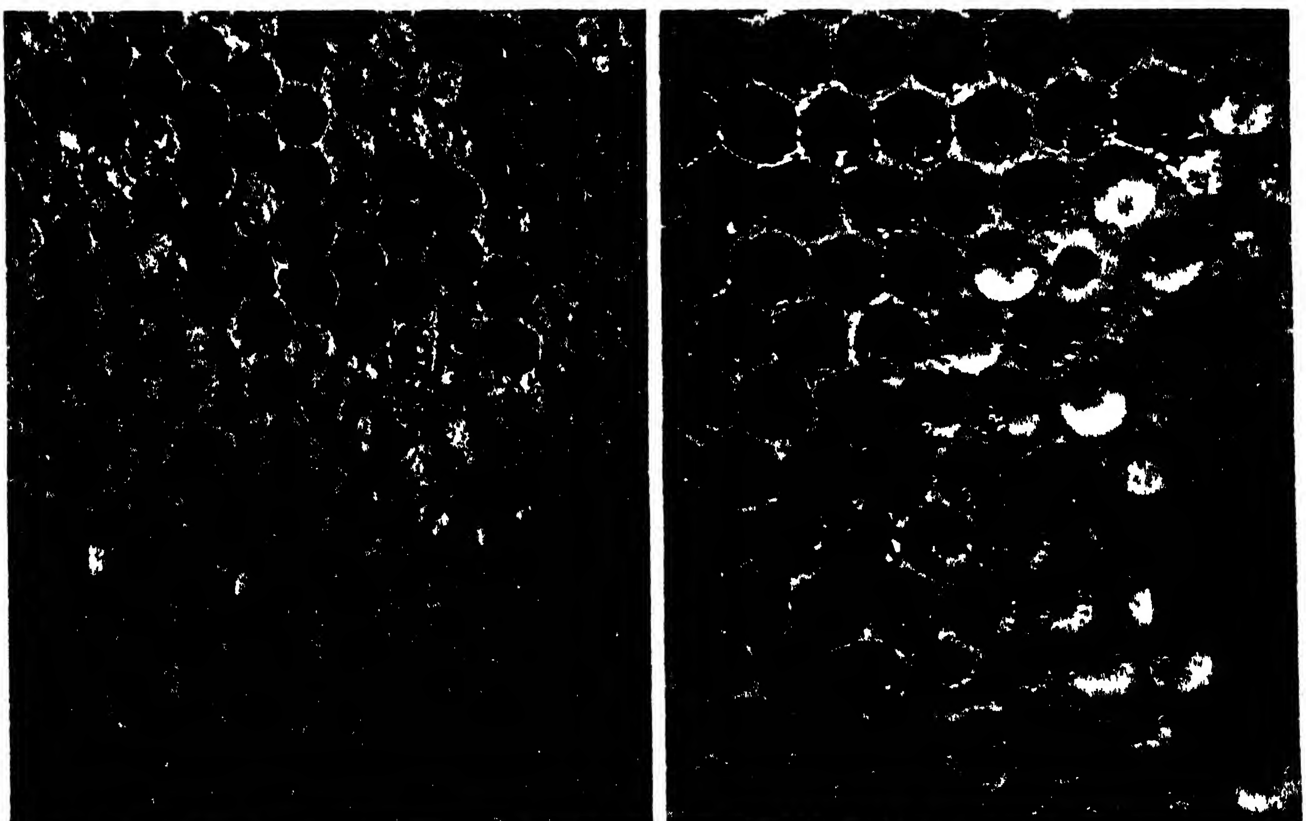
Here is part of the bee's hind wing, showing a row of tiny hooks which runs along its front margin. The function of these hooks is to link up the front and back wings, so that when the bee flies they will form a single pair

Stages in the history of a white clover blossom which has been visited by bees. The various florets turn downwards after fertilisation

THE WONDERFUL NURSERY OF THE BEES



Nowadays beekeepers place frames of wax in the hive from which the bees can make their comb. This leaves them free to devote more time to the production of honey, which is the substance their human owners want. When, however, bees are placed in an empty hive they make wax for themselves out of honey and render it plastic with saliva, so that it will stick to the roof of the hive. Other wax is added and soon the shapeless blocks are scooped out and formed into cells. Here we see various stages in the making of a comb



When the wax cells are properly formed the eggs are laid in the lower cells by the queen bee. In due course these hatch out into grubs, which are fed by the worker bees, and grow so as to fill their cells. They then spin a kind of shroud, and after the cell is sealed up the grub changes into a pupa and then into a winged bee, which gnaws its way out. These pictures show the comb with some cells sealed and others with the grubs inside. The upper cells of a comb are generally filled with honey, and pollen or "bee bread"

two stomachs, one being a honey sac and the other the stomach proper. The bee sips nectar from a flower and passes it down a tube into the honey sac. Another tiny tube lined with fine hairs, all pointing downward, leads from the sac into the stomach.

The nectar, as gathered, often contains some pollen grains, and the bee passes the nectar from the honey sac into the stomach and afterwards brings it back from the stomach to the sac, but the hairs pointing in one direction stop the pollen grains, and so nothing but pure honey enters the honey sac. Thus the opening between the two stomachs really forms a strainer. The honey sac, however, is very small and when full contains only about one-third of an ordinary drop of honey.

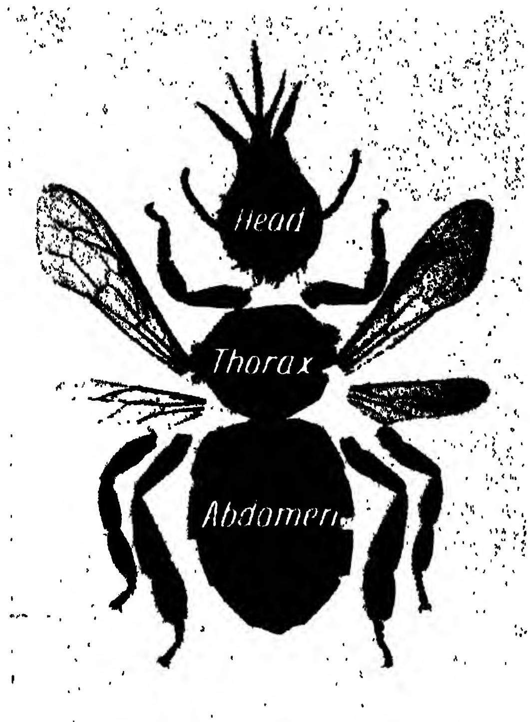
All over the body the bee has tiny air holes known as the spiracles, a word which comes from the Latin word meaning "to breathe." It is through these openings that the insect takes in air.

Then there is the sting, a useful weapon of defence. It is barbed, and consists of a sheath containing two tiny darts. When the bee stings it first pierces a hole with the sheath, and then the darts move up and down rapidly increasing the depth of the wound. At the same time, poison from a poison bag is poured into the wound, causing it to smart sharply.

The bee, however, is not an aggressive creature, and if one alights on a face or hand we must not get excited and brush it off, as in that case it will probably sting us; whereas if we leave the bee alone it is quite unlikely to insert its sting. The sting of a bee is fatal to other bees. The workers will often sting to death bees from other hives that enter their hive, and the queen, whose sting is curved, unlike those of the workers which are straight, uses hers to kill rival queens.

Of course, if bees are annoyed or frightened by human beings they will make a concerted attack and sting badly, but that even a mass of bees can be quite harmless is proved by the fact that sometimes when the bees are swarming they have alighted on a man's face and thousands have hung all round it like a beard, and yet he has come to no harm.

In another part of this book we read the marvellous story of life in the bee-hive.



A magnified photograph showing the various parts of a bee's body. In front is the tongue with its sheaths, and at the sides of the head the antennae or feelers

GROWING MUSHROOMS IN AN ENGLISH GLASS-HOUSE

It is curious that though no other country can vie with Great Britain in the large number of edible species of fungi that can be gathered at almost all seasons of the year, this form of food is not very much in favour in Britain.

The most generally eaten of all fungi in England is the common mushroom, and yet in some countries of Southern Europe it is regarded as unwholesome and almost poisonous. There is an old Italian proverb which says: "May he die of a pratiola," which is the Italian name for the mushroom.

The mushroom is common in the wild state, but it is also cultivated both in England and in France. Round Paris thousands are produced in caves, cellars, railway arches and disused tunnels. In England they are grown from spawn in special houses, and in covered beds in the open air. After planting the whole bed is coated with finely sifted loam to a depth of about an inch, and then over this is placed litter, which helps to keep in the moisture and preserve an even temperature.

Mushrooms must always be gathered fresh, as people have been poisoned by eating them in a decaying condition.

A large and well-formed specimen of the mushroom

Picking mushrooms in a glass-house in the Lea Valley, Essex

TELEVISION FROM THE BOTTOM OF THE SEA

Many of the difficulties and dangers of diving are due to the "blindness" of those in charge of operations on the surface. Moreover, visibility under water is usually bad and limited to a very short range. Scientists and engineers on the surface must depend upon what the diver tells them he can see, and as the pressure of the water at the greatest diving depths affects the diver's powers of observation his reports are not always reliable.

Salvage experts needed some device which would make it possible for them to see on the surface what the diver was doing and what he was examining. It would be even better if they could search for and then examine an under water object without having to send down a diver at all.

Both these problems were solved in 1951 by the development of a television camera specially designed to take pictures under water and then reproduce them on a screen in the salvage ship. Experimental work on the camera began during the 1939-45 War, but its first practical test was on June 14, 1951, when the British submarine Affray, which had been lost with all hands in the English Channel on April 17, 1951, was identified on the sea bed by means of an under water television camera.

Similar to those used by the British Broadcasting Corporation for outside television broadcasts, the under water television camera is enclosed in a water proof steel cylinder 28 inches long and 30 inches wide, and is surrounded by a metal frame to protect it against damage. Mounted on the frame are eight 150 watt electric lamps. Focusing, the opening and closing of the camera shutter, and the placing of the camera at any required angle are by remote control from the salvage ship.

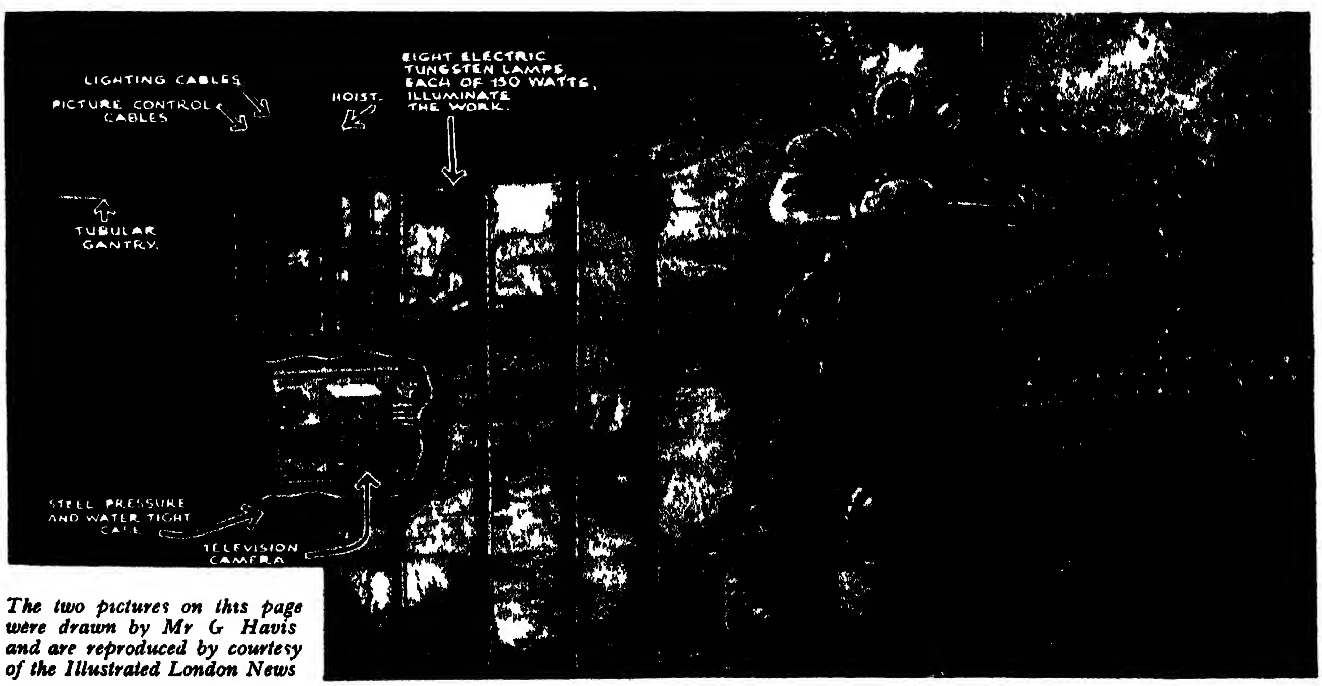
The camera is lowered by derrick to any depth to 1,000 feet and at once begins to take a moving picture of anything in front of the lens. The but later models are made self propelled by fitting them with an electric motor driving a propeller. The camera therefore moves about below water like a submarine, but remotely controlled from the surface.

This picture shows how the salvage officer can watch on a television screen on his ship a diver on the seabed. The officer and the diver talk to each other through a loud speaking telephone. The bottom picture shows the camera televising the diver at work

picture is reproduced on a television screen on the ship so that a surface observer sees exactly what the camera sees at moment of photographing.

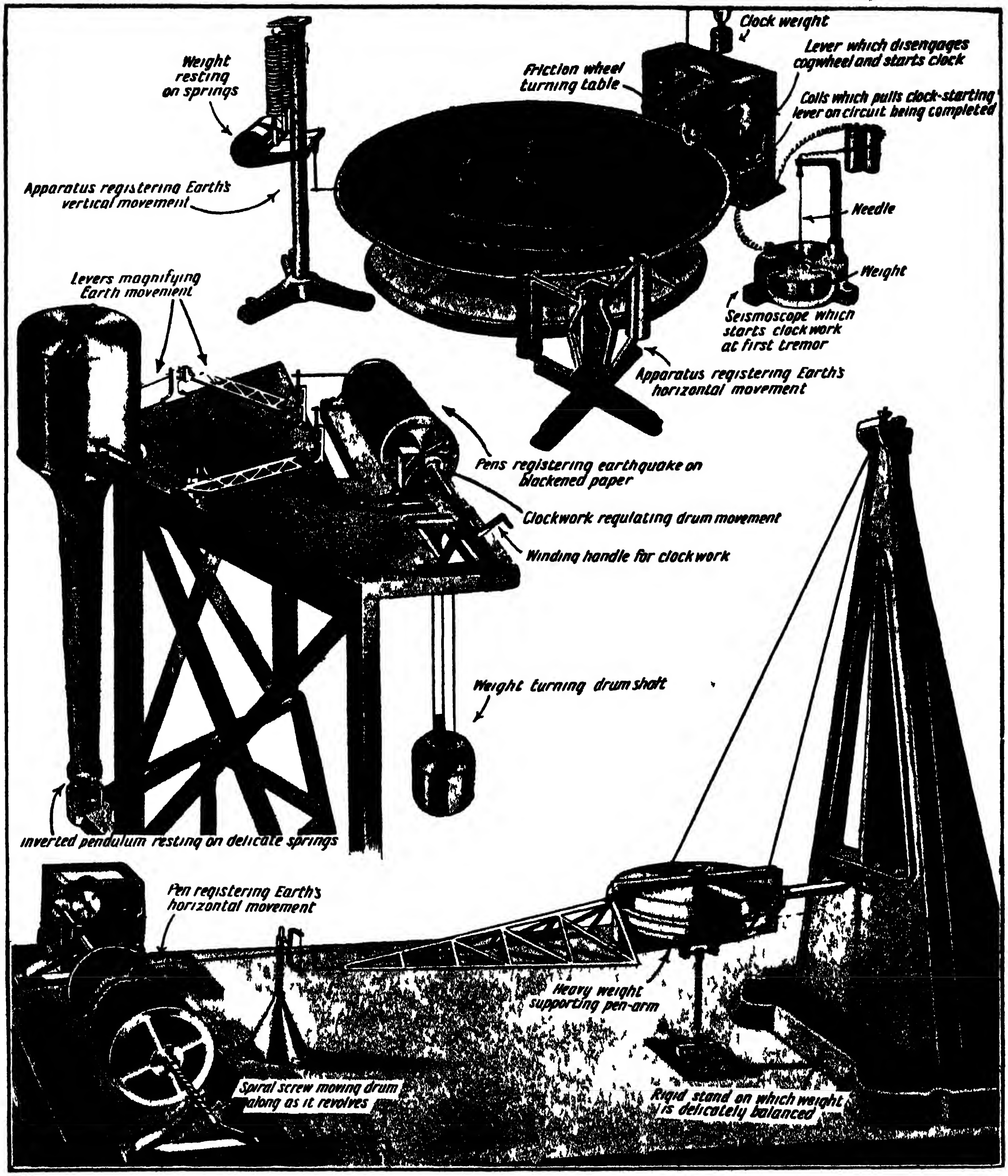
The first under water television cameras were moved by moving the ship from which they were suspended.

Under water television is now used for inspecting ships' hulls, harbour walls, dock gates and wrecks. Where divers are working under water television makes it possible for the salvage officer watching the screen to tell them what to do.



The two pictures on this page were drawn by Mr G Davis and are reproduced by courtesy of the Illustrated London News

THE INSTRUMENTS THAT RECORD THE EARTHQUAKES



One of the marvels of modern science is the seismograph, which records the slightest earthquake, no matter where it may take place Here are shown three forms of the instrument, but in all cases the principle is the same A heavy weight to which a pen is attached is very delicately suspended and rests on a fine point When the earthquake occurs the tremors pass round the globe, and as the earth trembles the buildings and various objects on its surface tremble also But the delicately poised weight does not take up the movement quickly like the other objects around it, and so the pen attached to the weight remains still, while a drum or table, covered with blackened paper, on which the point rests shakes with the earth, and a zigzag line is marked on it It is really as though we held a pen still while somebody moved the table or paper, and a writing was produced in this way In the case of all seismographs, by means of levers and long arms to the pens, the tiny vibrations are greatly magnified The instrument on the left and the one at the bottom are for recording horizontal movements of the earth The instrument at the top records both horizontal and vertical movements As soon as a tremor occurs an instrument called a seismoscope starts a clock, and the table begins to turn, so that continuous lines are made by the pens In the seismoscope a heavy weight resting on a pin-point pivot has a long perpendicular needle attached When the earth trembles the weight remains still, but the apparatus shakes, the tip of the needle touches the side of a small cup, an electrical connection is made, and the clock starts

WHY WE ARE ABLE TO SEE THINGS

When we look at things we do not see them all in the same way. If we look at a mirror we see not the glass, but ourselves and the things round about us, and if we look at a window we see not the glass, but what lies beyond. If, on the other hand, we look at the moon, or a book, or a tree, or a dog, we see it. This is because the light falling on the object is diffused or reflected in various directions and so lights it up as if it were giving out light of its own like the Sun or a flame. Here we read why this is

It is by means of our eyes that our brains are able to receive an impression of what things are like We can see whether they are round or square, tall or short, red or blue, and so on, and about the wonder of the eye itself we read in another part of this book.

But how is it that the eye is able to receive an image of the object at which it is looking, so as to pass on a message to the brain? Well, things are seen by means of rays of light, which pass to our eyes from the objects and strike upon the retina or curtain at the back of the eye.

Certain objects, such as the Sun, the stars, the electric light, the gas flame, are self-luminous, that is, they shine by their own light, and, as they burn, rays of light are caused, which pass through the intervening spaces to our eyes.

Yet there are other bodies which we see but which do not shine by their own light at all. In the sky, for instance, we have the Moon and planets, and then there are the things about us, such as houses and trees and furniture and books and pictures and these words which we are reading now. How are we able to see these things if they have no light? Well, the fact is we see them by means of the light that shines upon them from luminous bodies and is reflected to our eyes.

When a beam of sunlight or a ray of light from a flame or lamp shines upon a smooth, polished surface like that of a mirror, nearly all the light is reflected back, and if the beam strikes the mirror at an angle, the light is reflected at the same angle in the opposite direction.

When, however, a beam of light is allowed to fall on a rough surface like that of a sheet of unglazed white paper, the rays are not reflected at certain definite angles as in the case of the mirror, but are scattered in all directions by the innumerable little reflecting surfaces of which the surface of the paper is composed. This scattering of the light in all directions is known to men of science as diffusion, which simply means "spreading abroad."

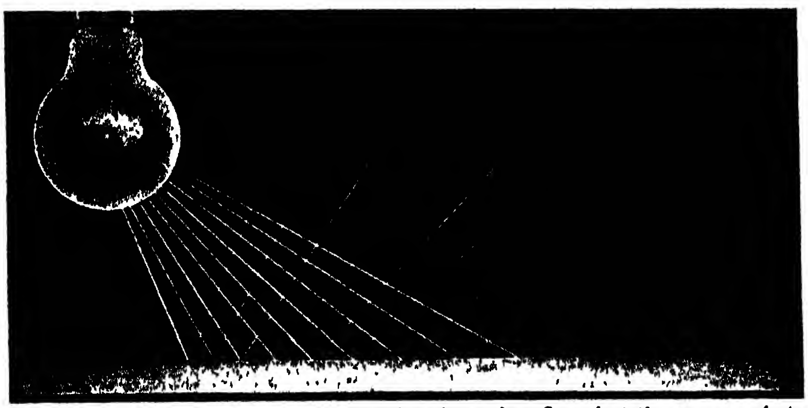
Now as a diffusing surface scatters in all directions the light which falls upon it, each small part of such a surface is sending out light in many directions, just as a small part of a luminous surface like a flame sends out light. We are thus able to see the outline of a diffusing surface as we do that of a surface which is itself giving out light of its own. For this reason we can see the Moon or a sheet of paper.

When, however, light comes to us from a polished, reflecting surface like a mirror we see, not the outline of the mirror, but the source from which the light reached the mirror, for the light is not diffused but is nearly all reflected back. That is why we cannot see the mirror itself.

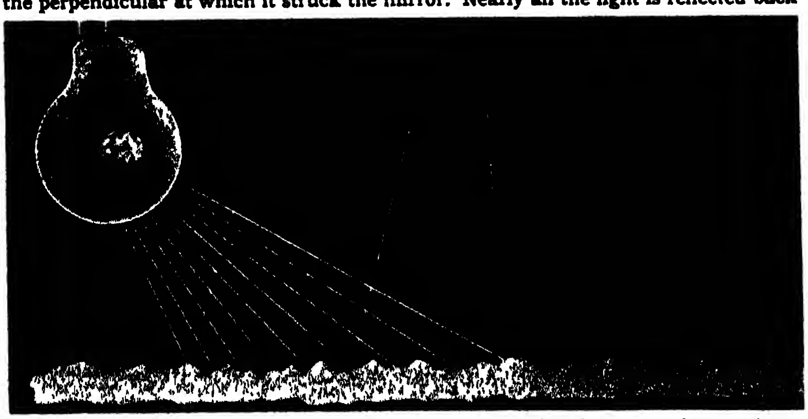
One result of this is that sometimes when there is a large mirror on a wall we may begin to walk into it before realising that it is a mirror, for the outline of the mirror is not noticeable to us. We merely see objects reflected in it. In the same way we may walk into a sheet of plate glass, because a perfectly transparent body allows the rays of light to pass through without illuminating its shape, and so we cannot see the glass.

All bodies other than those which are self-luminous can be visible only by the light which they diffuse or shed in all directions. Black bodies absorb the light which they receive and send back no light to our eyes. We should thus be quite unable to see a black body were it not for the fact that its outline can be distinguished by the diffused light which comes from the background. Any object which can be seen must be sending rays of light to our eyes.

We must remember that if it were not for diffused light our rooms would be very dim and dull. It is the scattering of the light in all directions as it is reflected from the walls and ceiling that lights up the entire room. Otherwise the room would be light only in that part upon which the rays shone directly from the source of light.



Here the light is falling on a mirror and each ray is reflected at the same angle to the perpendicular at which it struck the mirror. Nearly all the light is reflected back



In this picture we see how the light falling on a sheet of white paper, the roughness of which is much magnified in the drawing, is reflected in a variety of directions because the roughnesses are at different angles. The light is thus diffused, causing the sheet to appear illuminated as if it gave out light of its own

CENTRE OF GRAVITY EXPERIMENTS

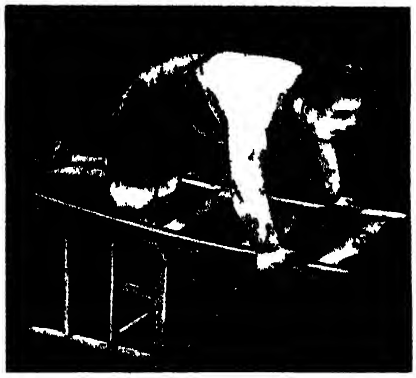
There are many interesting experiments which we can carry out to illustrate the principle of the centre of gravity, and some of these are illustrated on this page In the first experiment we place a fairly heavy stool close against the wall and then take up our position facing it with our feet on the ground just twice as far from the wall as the width of the stool

Now bending forward with our legs quite straight to the hips and our head resting against the wall as shown in the first picture we grasp the stool and raise it as in the second picture What we have to do now is while holding the stool to try to raise ourselves to the erect position without moving our feet or legs The displacement of the centre of gravity of our body now that we are holding the stool makes it impossible to reach the erect position

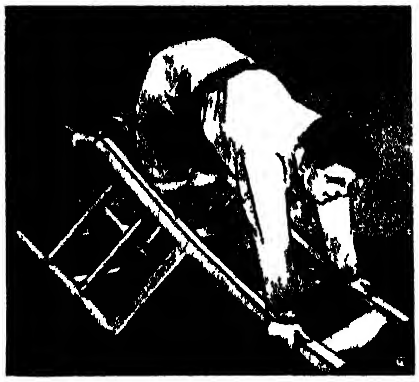
How to stand ready for the stool experiment

Having lifted the stool we find it impossible to rise to an erect position

In the second experiment we place a strong kitchen chair on the ground in the position shown with a piece of lump sugar on the upper rail Now kneeling on the lower bar of the chair and grasping the side rails we bend forward and take up the sugar with our lips The result will probably be as shown in the second of the two pictures The centre of gravity being displaced causes us to overbalance But by keeping the rear of our body well back and crouching low the sugar can be taken up without overbalancing



How the chair and sugar are placed



When we try to seize the sugar with our lips we shall overbalance unless very careful

For the third experiment we need a pencil and a ring One experimenter holds the pencil and the other has to try to place the ring over its point Before making the attempt however, each player has to hold up one of his or her feet with the hand as shown This necessitates the performer resting on one knee only and naturally it is very difficult to keep upright, as each player is in a state of unstable equilibrium like a peg top balanced on its peg

The experimenters each on one knee try to put the ring over the pencil without overbalancing

In the final experiment we need a broomstick or other pole, such as that which a boy scout carries The experiment is to rest one end in the angle made by the floor and the wall, and then to pass the whole of the body underneath it without moving the end of the pole and without overbalancing With our backs to the wall it will not be an impossible feat

How to stand ready for the pole experiment

With the back to the wall it is easy to pass under the pole and regain our position

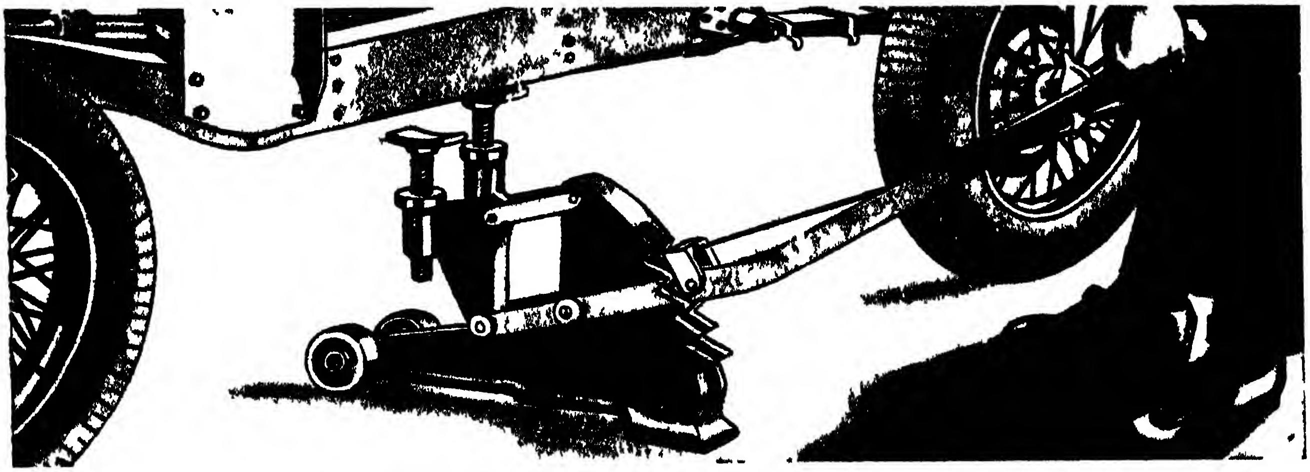
HOW A MAN CAN LIFT A GREAT WEIGHT

Of all simple machines the lever is the most familiar, and an adaptation of this which is in general use will be found in the lifting jack The device is better known to-day than ever it was, for everyone who has a motor-car uses a jack Here we read some interesting facts about the different types of jack and see how these operate

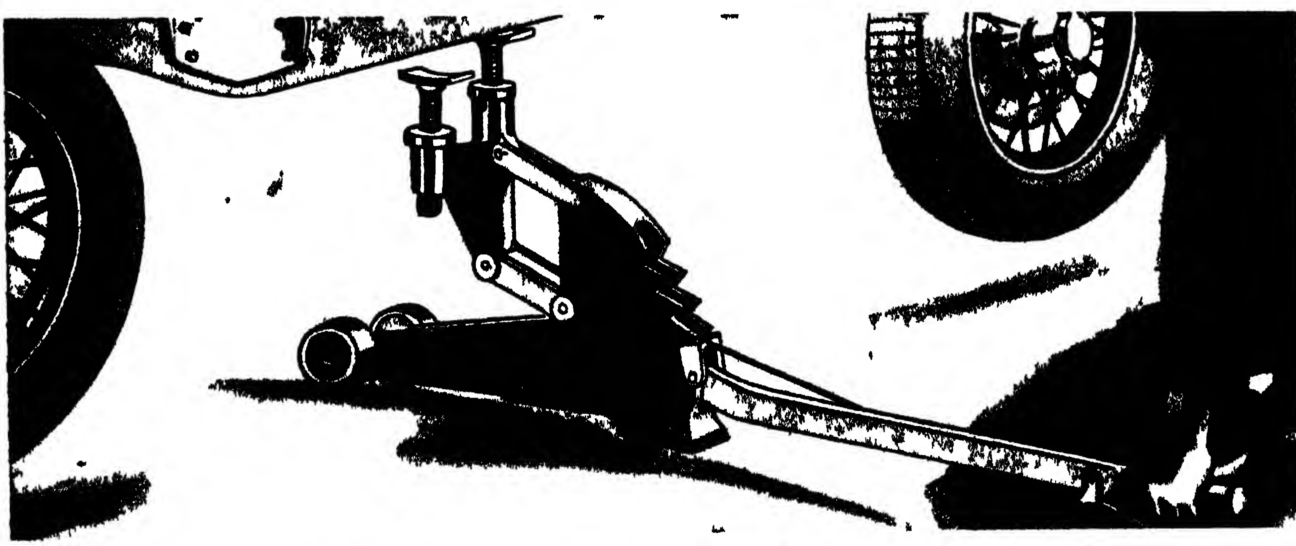
THERE are many devices which man has invented to enable him to do what, without the aid of any machine at all would be impossible We have seen for example how the lever enables him to move a weight which he could not do without the aid of a crowbar working on a fulcrum The pulley too which is described and pictured on pages 649 to 653 is really only an adaptation of the lever and by this ingenious arrangement a small force acting through a great distance will lift a heavy weight or exert a great force through a short distance

Perhaps the simplest adaptation of the lever for raising weights in every day use is the jack which lifts the weight from below instead of raising it from above as does the pulley It is a portable appliance and is made in a great variety of forms exerting a force varying from a few hundredweights to five hundred tons and is adapted to any special purpose for which it is intended – for use with motor cars railway trains locomotives bridges and so on

The simplest type of jack is a pivoted crowbar working in an upright frame which by mere pressure on the lever will give a direct and quick lift Such a jack now in common use in garages is shown in the pictures on this page



Here is a simple form of jack used in garages It consists of a pivoted crowbar and is a common type of quick lift jack used for motor-cars There are two independently adjustable heads which can be screwed up or down, and the long arm raises these while a pawl and ratchet mechanism enables the arms to be held in position when they have been raised The pawl is released by a catch near the end of the lever In this picture the mechanic is about to press down the long arm and raise a car



In this picture the mechanic has lowered the arm, thereby raising the vehicle which was to be lifted, and this is held in position by the pawl and ratchet, as can be seen The pawl can only be released when the lever is pressed down, so as to take the weight off the pawl Two wheels in front of the jack enable it to be wheeled about easily from place to place

A more advanced type of jack is that known as the screw jack, and this again has various forms, the screw sometimes being turned by means of a bar in the same way as a capstan is turned, and sometimes by means of a rotary handle and a system of gearing.

In the old days old timber houses which had sunk on their foundations so as to bend forward and be in danger of tumbling over, were often jacked up and then supported by props The jack used in such cases generally con sisted of a toothed wheel and rack, arranged in a wooden stock or frame, and when the wheel was turned the teeth engaged with the teeth of the rack and raised it slowly, lifting the house with it.

It has been said that when men use a machine of this sort great things are done slowly, whereas when they apply their own strength without a machine, small things may be done quickly. As we know, a machine does not increase power and speed at the same time. If power is increased it is done at the expense of speed, and this is the case with the jack. The man operating the jack may be working very rapidly, but the lifting that is done proceeds very slowly.

The jack was never so much used as it is to-day, for all motor-cars carry a jack, so that the vehicle can be lifted in case a new wheel or tyre has to be put on.

For heavier work hydraulic jacks are employed, in which a small plunger worked by a hand lever applies pressure to a liquid, and this pressure being multiplied over a wider area exerts a much greater force than that applied to the lever. The principle of the hydraulic press is fully explained on page 184, and that principle is the same in the hydraulic jack.

As water is liable to freeze in cold weather, and further, may cause rusting in the iron parts of the machine, oil is now more generally used as the fluid, and on this page one type of hydraulic jack utilising oil is shown.

Sometimes the screw type of jack is combined with the hydraulic principle. In heavy engineering some large jacks capable of lifting five hundred tons are used, and these of course work on the hydraulic principle.

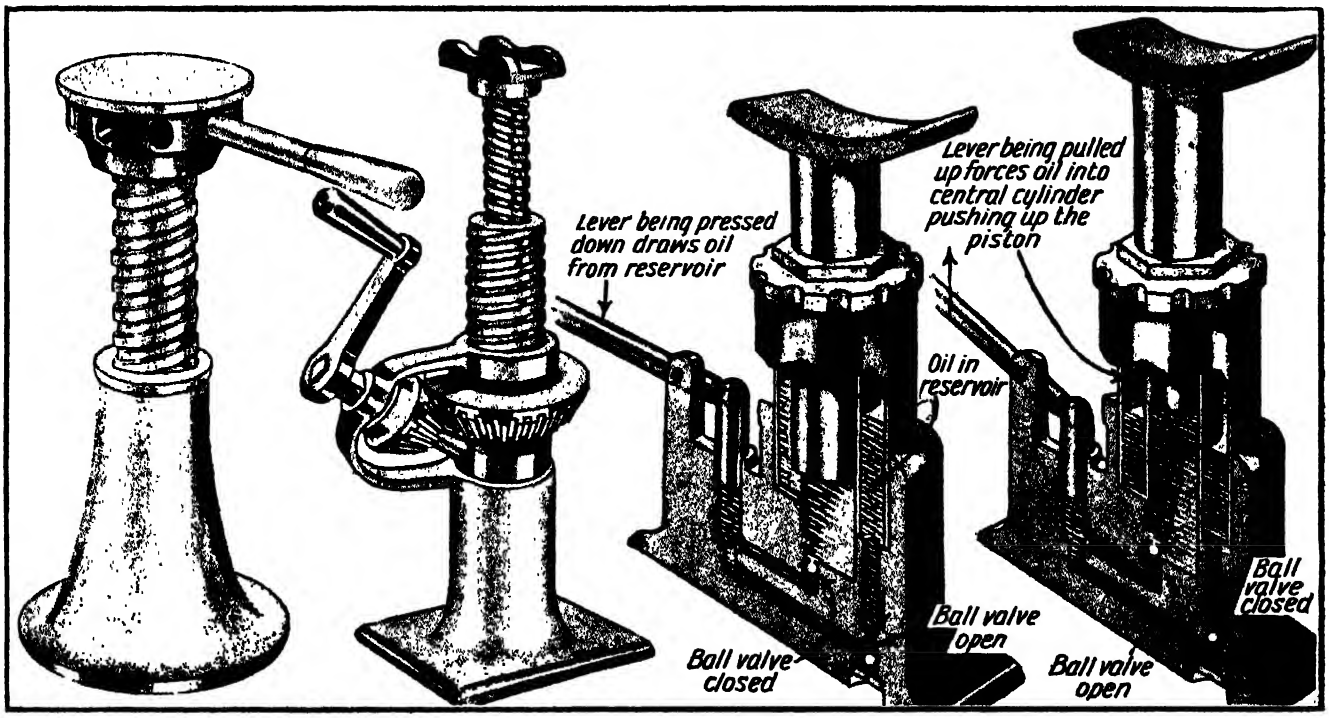
A very important use of the jack is in the replacing of locomotives and railway carriages upon their rails when they have become derailed.

Of course, in all cases it is essential that the base of the jack should rest upon a firm and level foundation If, for instance, in jacking up a vehicle the ground on which the jack stands should be soft, the application of the power is more likely to press the jack into the ground than to raise the load. In the case of damp, spongy ground, it is always wise to stand the jack upon a plank laid horizontally.

The use of the jack requires no particular skill, but it is, of course, necessary to take ordinary common-sense precautions. For example, when the front part of a car is being jacked up the hand brake should be applied to prevent the car from running backward, and when the car is being jacked up at the rear wedges should be placed on each side of the front wheels to prevent any forward movement.

In a traversing screw jack the lifting part can be worked to and fro on the base by means of a horizontal screw worked with ratchet levers.

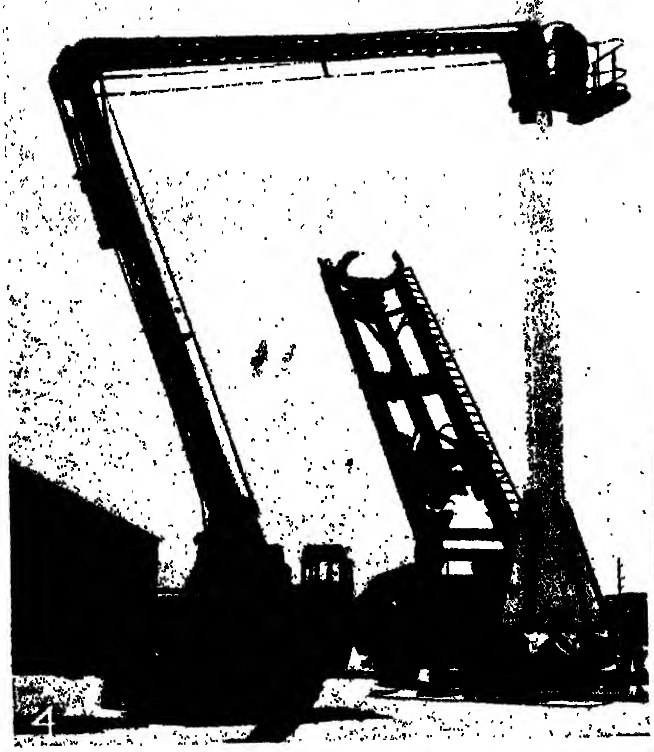
It is interesting to know how the name "jack" came to be given to an appliance of this kind. As the familiar form of the commonest of all Christian names, John, it came to be used for any boy or man who did rough or menial work. Then the name was transferred to any contrivance which did the work of a common servant, or to anything which was put to rough use, such as a boot-jack or roasting-jack, and thus it came to be used for a simple machine for lifting the axle of a vehicle off the ground while the wheel was being cleaned.

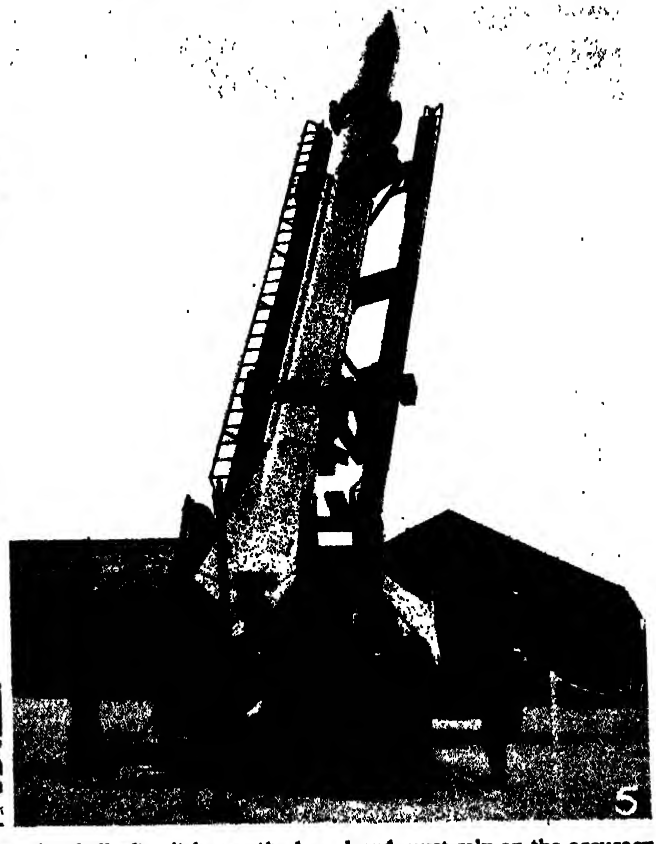


In this picture we see several kinds of jacks. The first one is an ordinary screw jack, which is raised by turning round the head with an arm. It is the simplest form of screw jack. The second picture shows a more complicated form which is known as a double lift screw jack. By means of a rotatory handle bevelled gearing is turned, raising a screw inside which works a smaller screw, carrying the head of the jack. As the handle is turned the whole series of screws is operated, and the jack is raised slowly. The last two pictures show a hydraulic jack working not with water, but with oil, which does not freeze or cause the metal to rust. When the lever is pressed down a plunger is raised and oil passes from the reservoir through a channel into the chamber in which the plunger works. At this operation a ball valve closes the entrance to the central chamber, but another ball valve on a spring is pushed down by the oil in the reservoir, so that the oil can pass to the plunger. When the lever is raised the ball valve entrance to the reservoir rises on its spring and closes the channel, while the pressure of oil by the plunger pushes up the ball valve of the central chamber, and the oil entering raises the central cylinder with the load

BRITISH ARMY'S FIRST GUIDED MISSILE REGIMENT

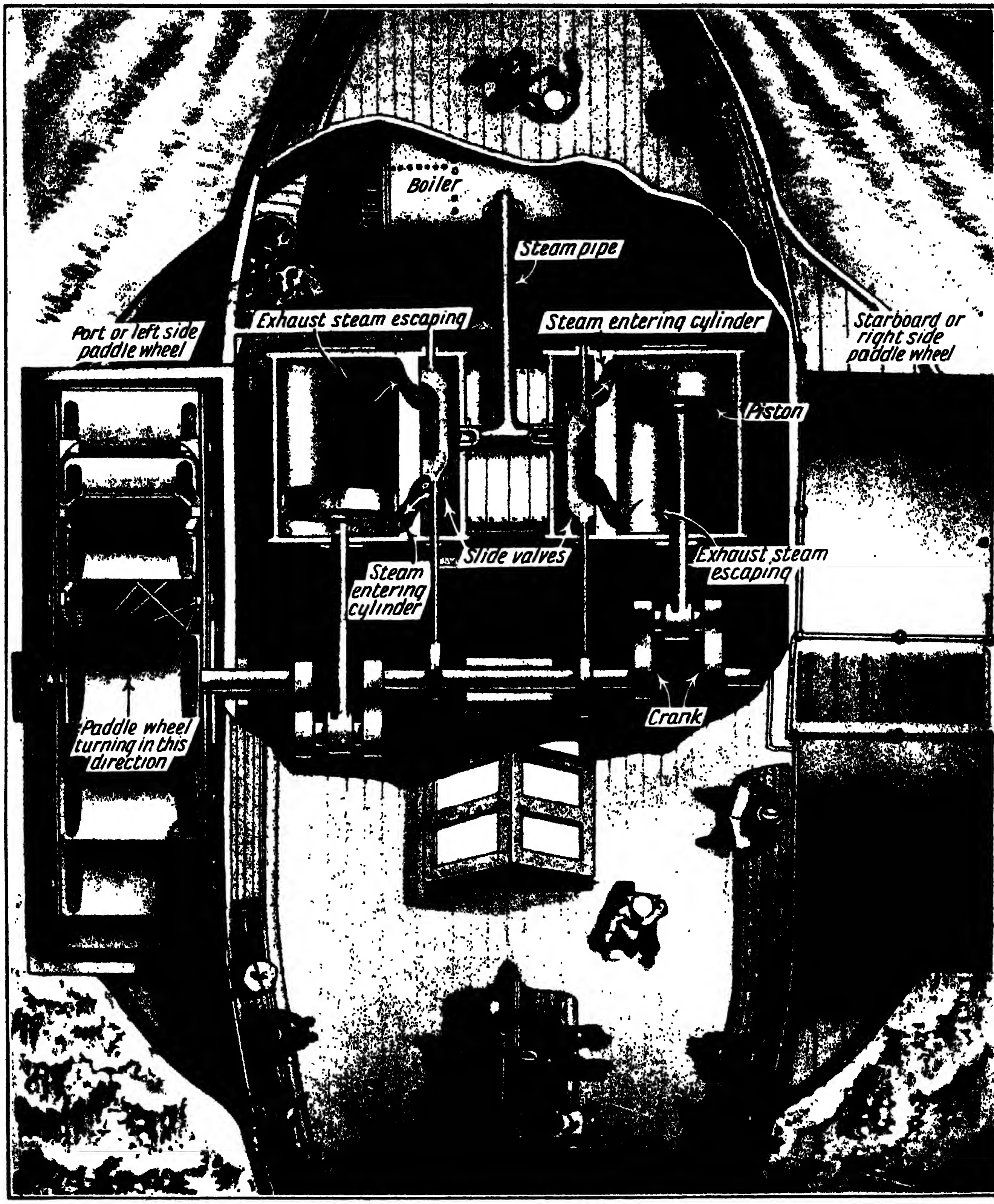
The British army's first guided missile regiment of the Royal Artillery was formed in 1957 and armed with Corporal weapons supplied by the U.S.A. The Corporal guided missile is 45 feet long, 30 inches in diameter, and weighs 5 tons. It carries an atomic warhead which has an explosive effect equal to that of 10,000 tons of T.N.T. The missile is powered by a liquid fuelled rocket motor and is guided to its target by radio and radar. The photographs on this page show the Corporal being made ready for firing. 1. Preparing to fuel the missile's rocket motor from a pressure tanker. 2. Members of crew in protective helmets and clothing. 3. N.C.O. signalling that fuelling is completed. 4. Men on a servicing platform at the end of an adjustable arm preparing missile for firing. 5. Transporter cradle raising missile to its vertical firing position.





When an ordinary gun is fired, the artilleryman has no control over the shell after it leaves the barrel and must rely on the accuracy of his aiming and ranging instruments to hit the target. Now science has produced the guided missile. This has a wonderfully ingenious electronic brain which " thinks out for itself " the best way of scoring a hit

HOW A PADDLE STEAMER IS DRIVEN ALONG



In this picture we are looking down upon a paddle steamer, and part of the deck has been cut away to show us the engines at work driving the paddle wheels. Steam is generated in the boiler by furnaces and passed by a steam pipe to cylinders, where pistons are driven to and fro as in other steam engines of the piston type. Sliding valves enable the steam to enter first one end of the cylinder and then the other. In this way the piston is driven to and fro in both directions, the exhaust steam of the previous stroke being driven out by the piston on its return. By means of piston rods, cranks are turned, revolving the shaft connected with the paddle wheels, and so the wheels are turned, and the paddles as they strike the water push the ship forward. Paddle steamers, which were the earliest form of steamship, are now mostly used for river and coastal services

HOW THE ATMOSPHERE IS MADE IMPURE

It is of the greatest importance if we are to keep healthy that we should take no harmful substances into our bodies. We must eat only pure food, drink pure water, and breathe pure air. Yet in large areas of Great Britain to-day the air is so polluted by soot and smoke that it is really unfit to breathe. Here we read something about this evil, which should be abolished

It is a very extraordinary thing that while in civilised lands the greatest care is taken to see that the water which people have to drink is absolutely free from contamination, the purity of the air is almost ignored. Yet it is just as important that we should breathe pure air as that we should drink pure water and eat pure food.

If there is the slightest suspicion of taint about the water supply of a district experts immediately get to work, and people are no longer allowed to draw from the supply till it is quite clear that it is pure and fit to drink

The same care is exercised with regard to the food we eat. Inspectors are constantly taking samples and examining the food supplies in markets and shops to see that nothing tainted reaches the people, and of course we are all very glad that this is the case.

But it seems strange that in regard to the air we breathe, and upon which we are dependent for life, very few precautions are taken to see that it is fit to enter our bodies. After all, we eat only two or three pounds of food a day, and in all forms drink only four or five pounds of water. Yet we consume forty pounds of air daily, and it is possible to take in with this a great deal of impure matter that is liable to cause disease.

As we have already seen on page 45, the black fogs from which so many cities suffer are due to the soot thrown out by chimneys, not only the chimneys of factories, but those of dwelling houses also. As the result of very careful tests and the collection of many samples, it has been proved that on a really foggy day a man walking in the streets of London takes into his body with the air he breathes about fourteen thousand million soot particles every hour.

It is the countless particles of soot thrown into the air from chimneys in towns and cities that give rise to so much fog and cause the fogs to become dense and black.

Dr. J S. Owens, an expert who has studied air pollution for many years, estimates that two-and-a-half million tons of soot are distributed broadcast over Britain every year This is not only harmful, but foolish, for soot is due to improper and incomplete combustion of the coal, and there are thus two-and-a-half million tons of good, unused fuel being thrown away

Some cities and towns, of course, take care to make laws prohibiting any considerable pollution of the air by chimneys, but there are plenty of other towns which take no steps at all to minimise the danger.

In large industrial towns the chimneys pour out vast quantities of smoke, polluting the atmosphere, as can be seen in this photograph, taken in the Potteries. The smoke consists of soot, and when this is breathed in by human beings it is very harmful to health, as can be imagined. The chemicals in the soot also do much damage to stone buildings besides making them grimy

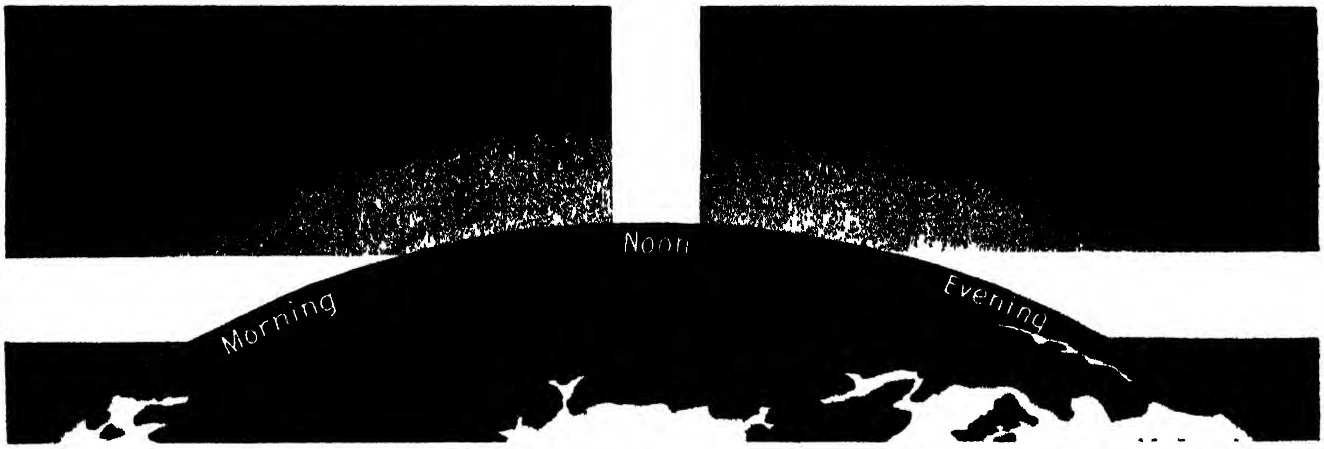
WHY MORNING AND EVENING ARE COOL

The morning and evening as we know are cooler than the middle of the day, and perhaps some people may wonder why this should be The reason is clearly explained in the picture diagram given here

At noon the Sun is shining down from its highest point in the heavens, so that area of the Earth's surface than it is at noon Naturally, therefore, when the same amount of heat is distributed over a wider area, there is less of it for each fraction of that area, and so the temperature is less than it is when the Sun is shining directly down.

Morning and evening are cooler than book. The Sun at midsummer is shining much more directly upon our part of the Earth, owing to the Earth's tilt, than it is in spring and autumn, and so the same amount of sunshine is concentrated on a smaller area.

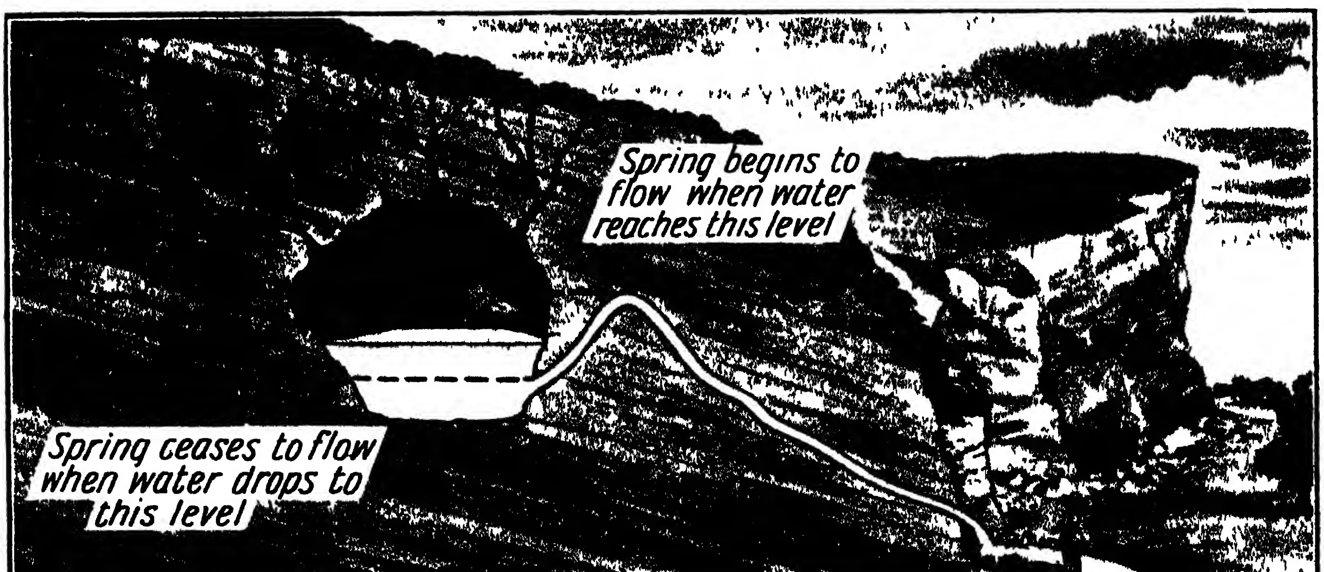
There is one other reason why, when the Sun's rays strike slantingly, they



This picture shows how rays from the Sun falling upon the Earth slantingly at morning and evening are spread over a wider area of the Earth's surface than when they come down more directly at noon. For this reason morning and evening are cooler than noon

the rays reach the Earth in the most direct way But in the morning and evening the Sun's rays strike the Earth at a slant, as shown in the picture The result is that the same amount of sunshine is spread over a much wider noon because each district receives less heat in a given time than it does in the middle of the day It is really the same kind of thing that happens at different seasons of the year, as we see from a picture-diagram in another part of this give less warmth. Not only do fewer rays fall upon a given area, but these rays pass through a greater thickness of the Earth's atmosphere, which absorbs more of their energy. The rays that fall directly come through less air

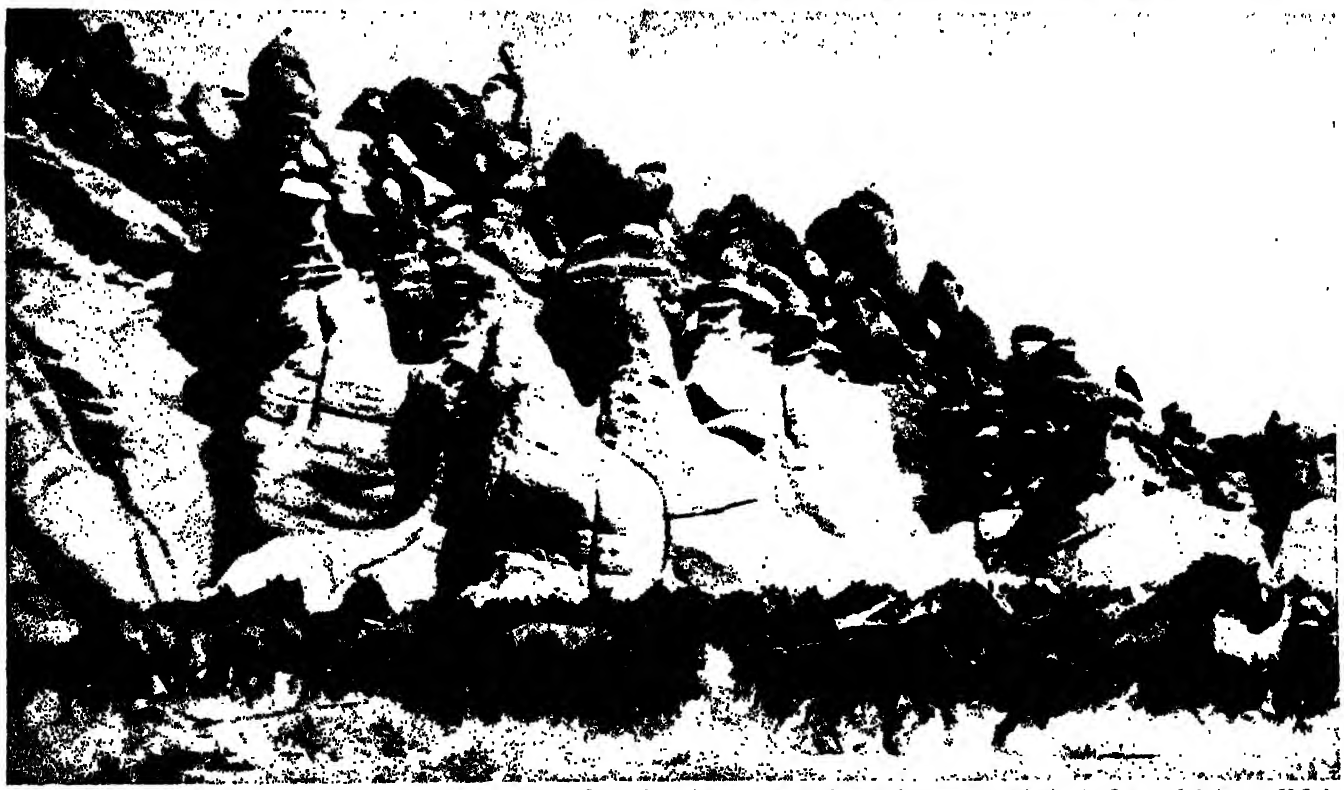
WHY SOME SPRINGS FLOW ONLY AT INTERVALS



There are scattered about the country certain springs which are known as intermittent springs, because their water flows only at intervals. The water will pour out of the hillside, perhaps for several days or it may be a week or two, and then it will suddenly cease. After an interval the water begins to flow again, and continues for about the same time. Then again it ceases. Why is this? Well, the picture explains the matter by showing that the outlet of the intermittent spring is really a siphon, and the working of a siphon is fully explained on page 598. Rain-water percolates through the earth into a cavern till it reaches the level of the bend of the outlet channel, when the short arm is filled with water owing to water finding its own level. It then flows over into the long arm, which becomes filled down to the outlet, and the column of water in the long arm being heavier than that in the other, flows out, and continues to do so till the water in the cavern reaches the entrance to the short arm, when air rushes in and the flow ceases. No further flow takes place till the cavern in the course of time is again filled with water to the level of the bend

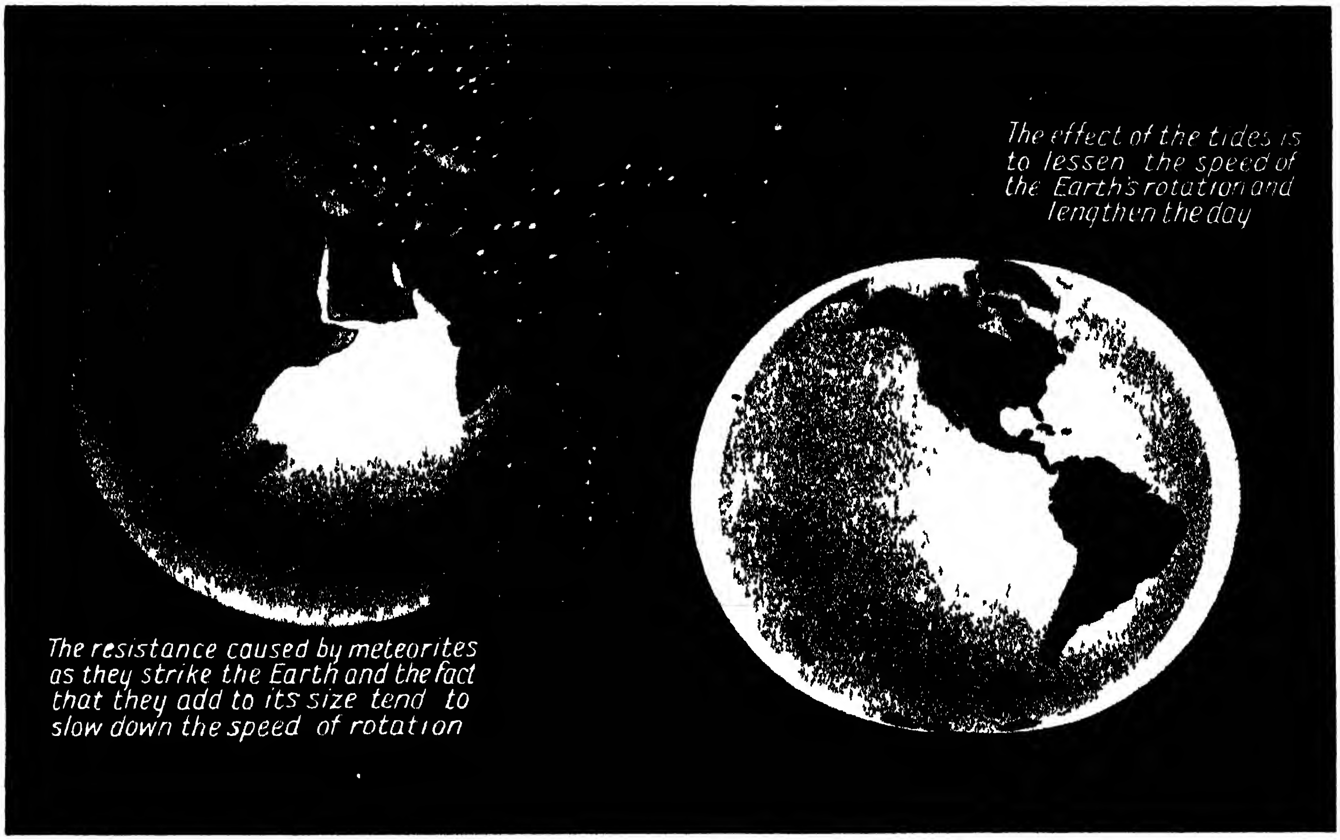
NATURE AS A MODERNIST SCULPTOR

There is nothing new under the Sun, and as can be seen in these photographs the work of Nature wrought upon the rocks by sea and wind and weather in many respects resembles the products of some of our modernist sculptors. This picture shows the rocks at Beachy Head in Sussex, where the wearing away of the hard material by the constant rubbing against it of the stones carried to and fro by the tide has left a row of rocks that are extraordinarily like inverted elephants' feet, suggesting that numbers of these animals lie buried beneath

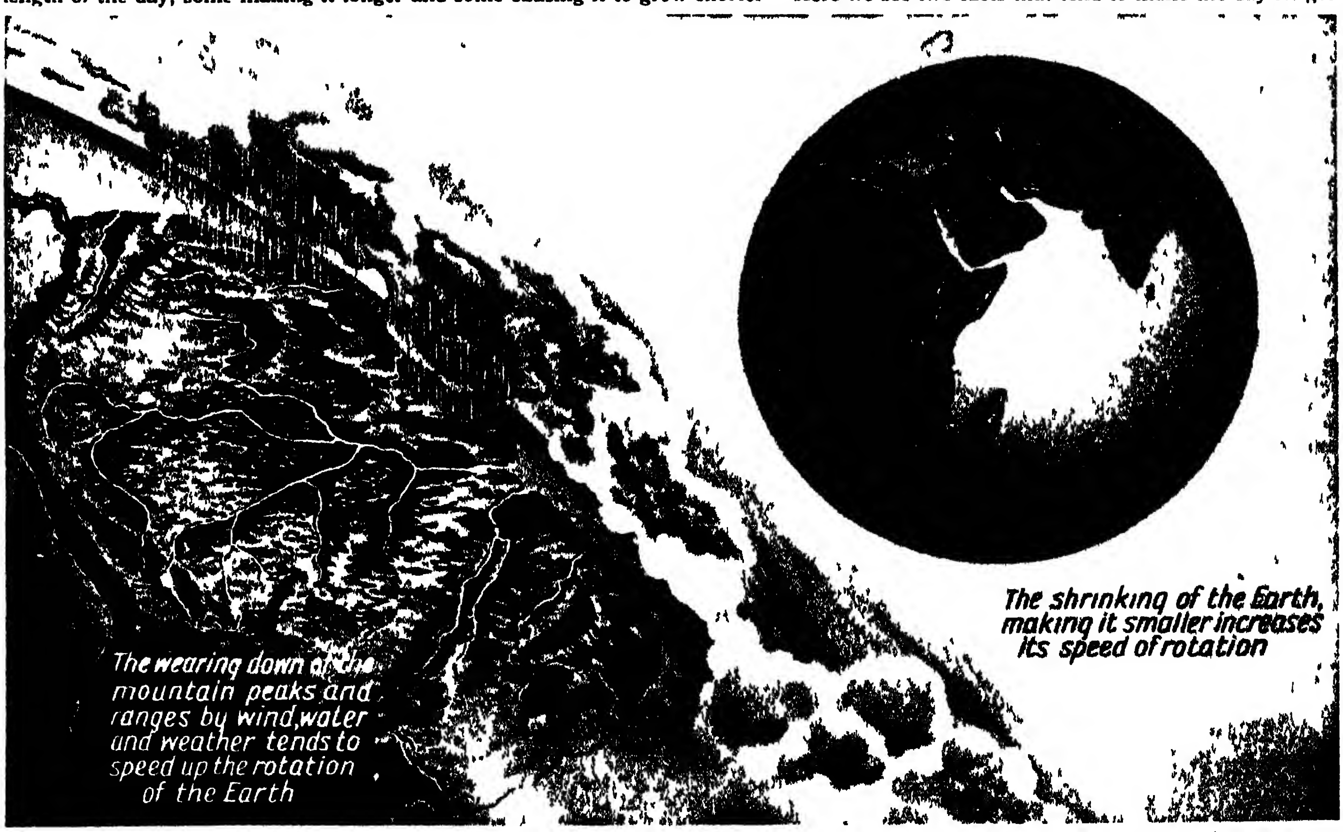


Many an art exhibition has sculptures that show little more form than these grotesquely weather-worn rocks in the State of Arizona, U.S.A. This sculpture has been done mostly by the sand carried against the rock by the wind, which has through the centuries worn away the softer parts of the rock, giving the impression of hand sculpture. Below is a herd of wild horses, one of which has just been lassoed

FACTS THAT CHANGE THE LENGTH OF THE DAY



The Earth turns round on its axis in 24 hours, and that is the length of our day But there are many facts which tend to change the length of the day, some making it longer and some causing it to grow shorter Here we see two facts that tend to make the day longer



In this picture we see two facts that tend to speed up the rotation of the Earth and make the day shorter. As the Earth shrinks it gets smaller and the wearing down of the mountain peaks also makes the globe smaller. As it gets smaller it tends to rotate more rapidly

WONDERS OF THE SKY

WHAT WE LEARN FROM A SOLAR ECLIPSE

A total eclipse of the Sun is always an interesting phenomenon, and even people with little or no education or knowledge of astronomy are interested in watching the Moon pass between the Earth and the Sun. But to the astronomer a total eclipse of the Sun is a great event, for in the few minutes that it lasts much can be learned that it is not possible to learn at any other time. In these pages we read something about the knowledge that is gained during a total eclipse

THERE are many things about the Sun that can be learned only during a total eclipse. During the period of totality, when the Sun's bright disc is completely blotted out by the Moon, there is seen round the dark face of the Moon what is known as the Sun's corona, a halo of light varying in extent in different eclipses.

The corona has been known from ancient times as a very beautiful and impressive natural appearance. The part closest to the Sun is exceptionally bright, and has a pearly tinge which presents a very marked contrast to the scarlet prominences or vast flames which are thrown up from the Sun's surface, which also are very prominent during a total eclipse.

The corona is made up of rays and filaments of light, which, although they diverge radially from the Sun, are not straight, but curved and very much intertwined. At those parts of the corona farthest from the Sun itself the light becomes diffused, and finally fades away. The corona is not always continuous, but there are often dark rifts extending sometimes to the Sun's surface.

This remarkable and brilliant phenomenon can be seen only during an eclipse, although many attempts have been made to distinguish it during the ordinary daylight. It is unlikely, however, that it will ever be seen except during a total eclipse.

Astronomers tell us that even the brightest part of the corona, that nearest the Sun's surface, is only about one-tenth as brilliant as the daylight sky 20 degrees from the Sun, viewed from sea level. Closer still to the Sun the daylight sky is many times brighter, and the corona therefore is quite insignificant in comparison.

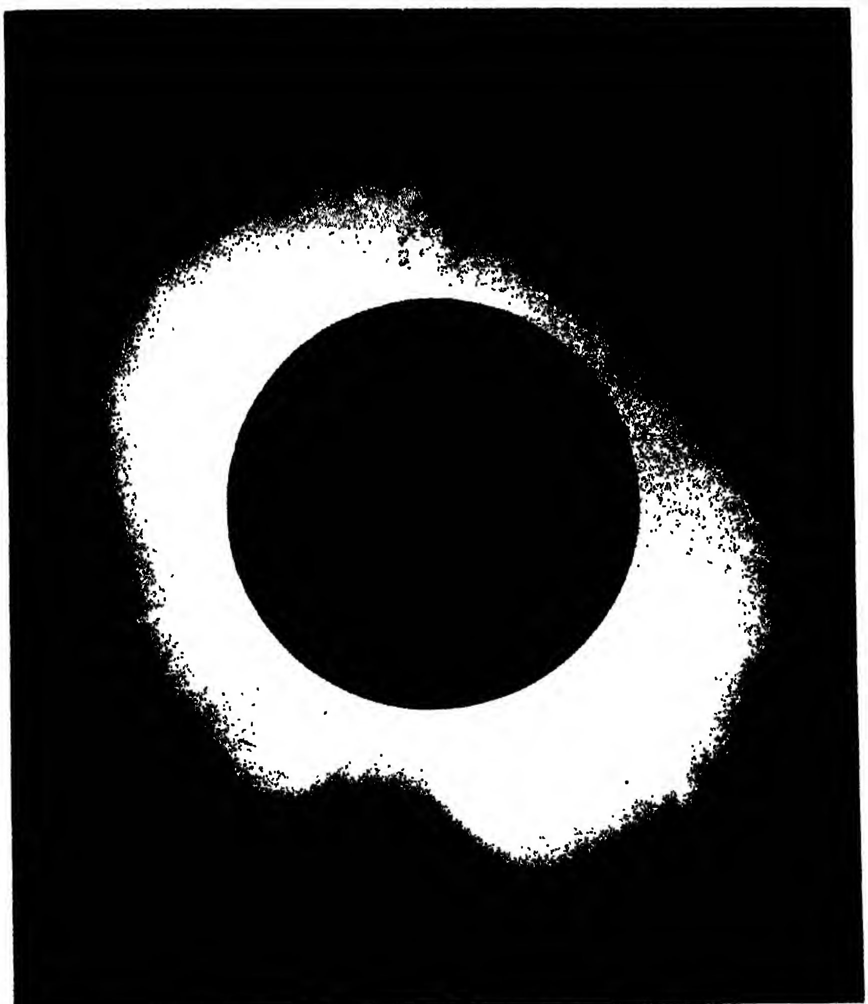
The corona has been studied by astronomers with some care during the past couple of centuries, and more is learned about it as time goes on. But as total eclipses are not frequent, and the period of totality in each eclipse is only a few minutes, the opportunities of studying the corona are very few and far between.

What is its nature? It is believed to consist partly of gaseous matter and partly of meteoric dust, but the matter must be very rare and drawn out, for comets pass through the corona without any apparent slowing down of their rate. The meteoric dust is probably white-hot, and shines by its own light, and the gas also shines by its own light. But it is believed that the outer parts of the corona shine by reflected light from the Sun itself.

A spectrum taken of the corona shows some gas unknown on Earth, and this has been given he name of coronium. Some think that this is a chemical element lighter than hydrogen, at present the lightest of all known elements. It is believed to be a substance which has not yet been discovered on the Earth

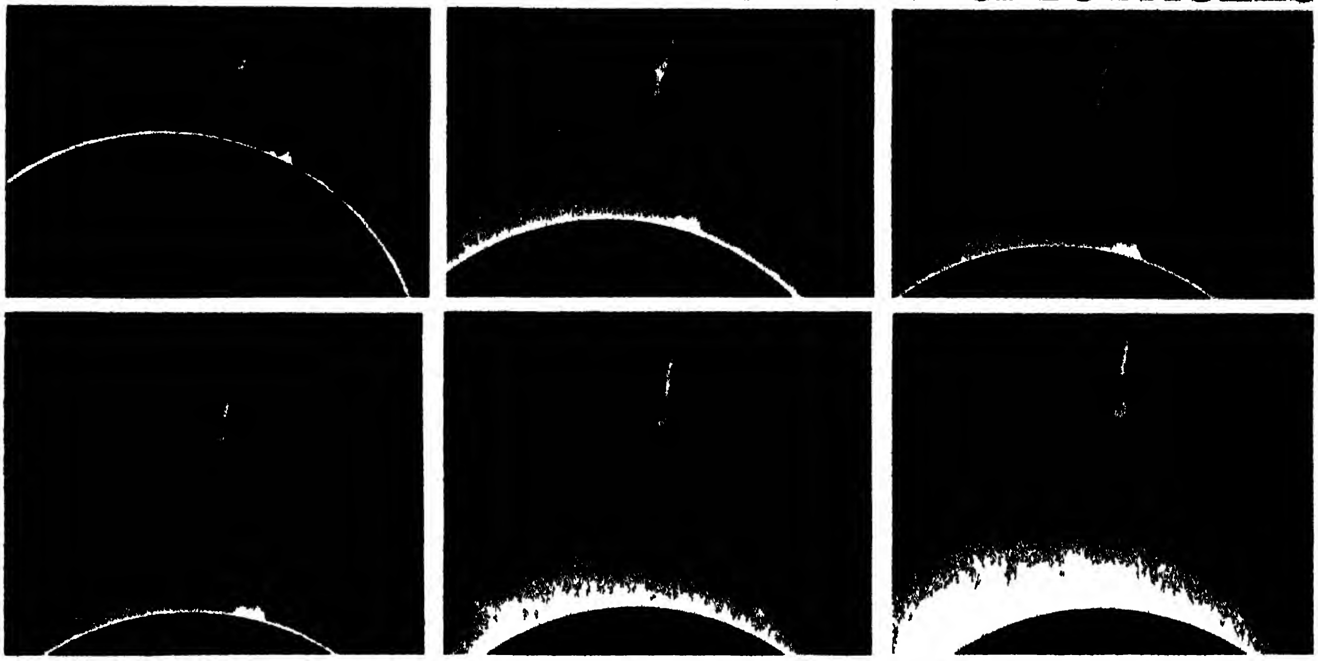
Some astronomers think that part of the light of the corona may be caused by electrical discharges, in the same way as an aurora is caused.

Observations during recent solar eclipses have suggested that the corona has something to do with sunspots, for it has been noticed that when sunspots are at their minimum large extensions of the corona appear at the Sun's

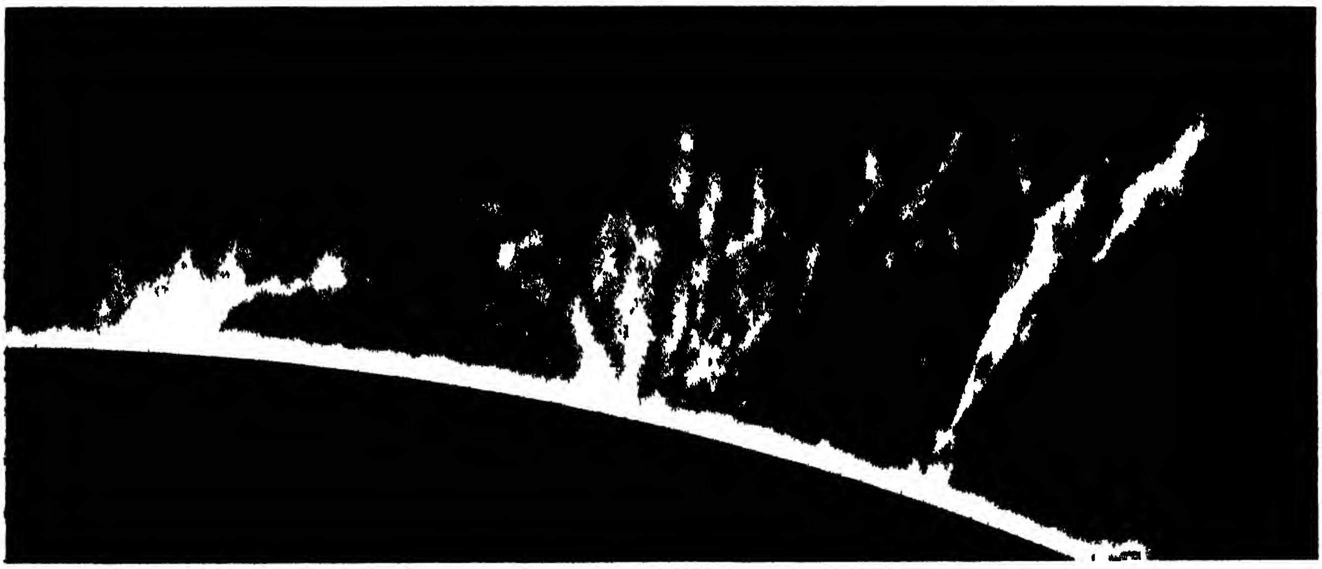


The wonderful solar corona that was seen during the total eclipse of the Sun on May 29th, 1919. The photograph was taken by Dr. A. C. D. Crommelin, of Greenwich Observatory, who went to Sobral in Brazil to study the eclipse

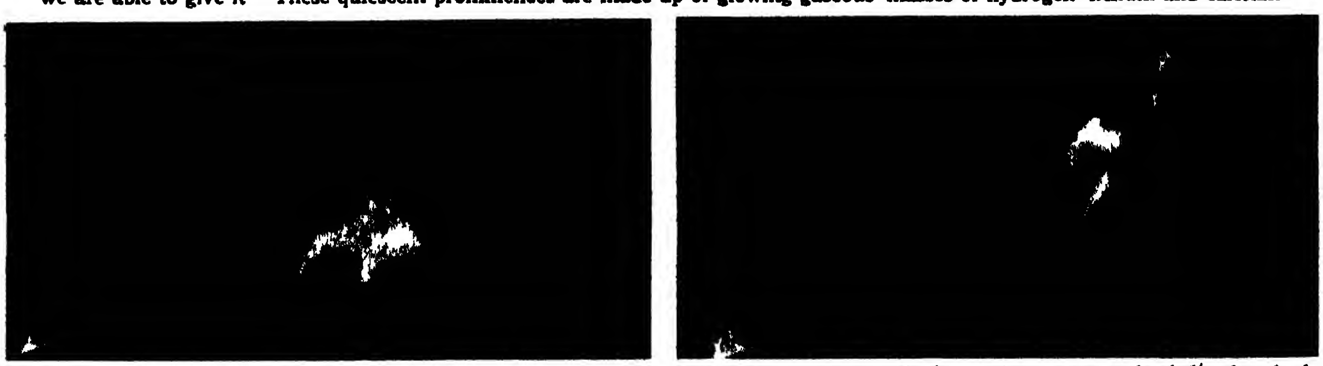
ONE OF THE GRANDEST OF ALL SPECTACLES



A very remarkable series of photographs taken during the total eclipse of November 19th, 1928, and given here by courtesy of the Royal Astronomical Society. It shows the development of a great eruptive prominence, that is, a mass of glowing gas which in just over an hour was shot up to the incredible height of 567,000 miles. The first photograph here was taken at 7 52 and the last at 9 3

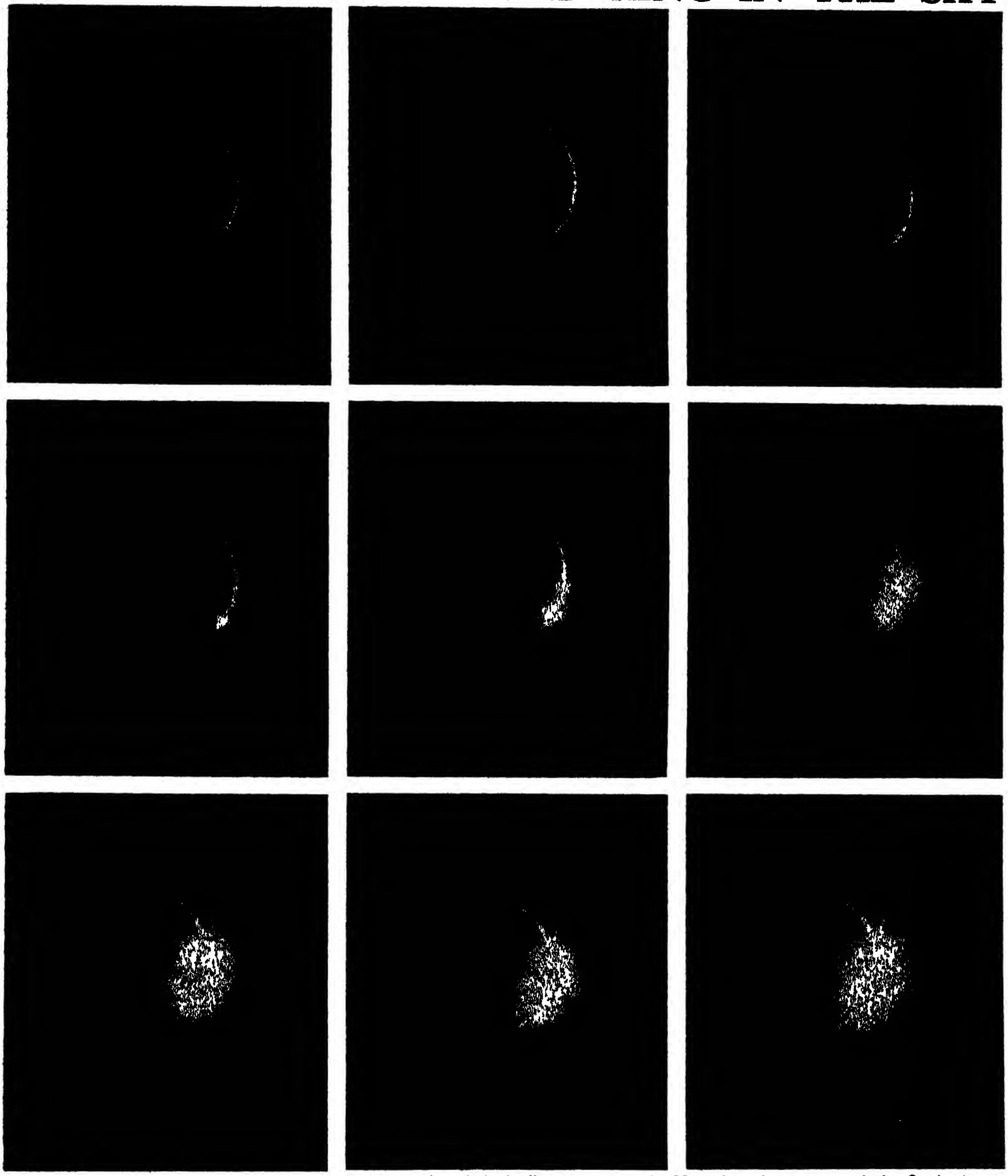


This fine photograph of a quiescent solar prominence 80,000 miles high was taken at Mount Wilson Observatory, by whose courtesy we are able to give it. These quiescent prominences are made up of glowing gaseous masses of hydrogen helium and calcium



Two photographs taken at the Yerkes Observatory, U.S.A., showing an eruptive prominence which in a short time was hurled up hundreds of thousands of miles. This type of prominence contains not only hydrogen, helium and calcium, but numerous metals including magnesium and iron. Such a prominence forms one of the most awe-inspiring of all natural spectacles

THE BRILLIANT DIAMOND RING IN THE SKY



During a total eclipse of the Sun when the last streak of sunlight is disappearing as the Moon has almost covered the Sun's disc, a strange appearance is seen. The bright edge of the Sun seems to be broken up, giving the appearance more or less of a string of beads. This phenomenon is called Baily's Beads, after the astronomer Francis Baily, who described it in 1836. Baily's Beads, however, had been seen more than a century earlier by Edmund Halley, discoverer of Halley's comet, during the total eclipse of 1715. The same phenomenon is also seen at the end of the total phase of an eclipse, and it is seen in annular eclipses, when the Sun appears as a thin ring round the Moon, which does not altogether eclipse it owing to its distance from the Earth. The phenomenon of Baily's Beads is due to irregularities on the Moon's surface, so that the light of the Sun shines through the spaces between the various lunar mountains and craters. Sometimes, where at one point the edge of the Moon's disc is very irregular, more light comes through, giving the appearance of a diamond ring, and this can be seen in this remarkable and unique set of photographs, which were taken during the total eclipse of August 31st, 1932, with a telephoto motion-picture camera, at slow speed, by Mr. Cleveland P. Grant, at Camp Wigwam, Harrison, U.S.A. It is the finest series of photographs of the phenomenon of Baily's Beads ever taken

equator, and there are plumes or tufts of light at the poles When, however, the sunspots appear at their maximum, then the corona is more or less evenly distributed all round the Sun

The spectrum of an aurora and the spectrum of the corona show great similarities It is very difficult to get accurate representations of the Sun's corona for photographs bring out far less detail than is visible to the eye But on the other hand, when artist astronomers draw the corona as they see it the pictures vary enormously

At one time it was thought that the corona had no real existence but was merely an optical illusion, due either to the light being seen through the Earth's atmosphere or reflection from the Moon But careful examination of many spectra taken hydrogen that are thrown up for hundreds of thousands of miles, are also seen at their greatest advantage during a total eclipse

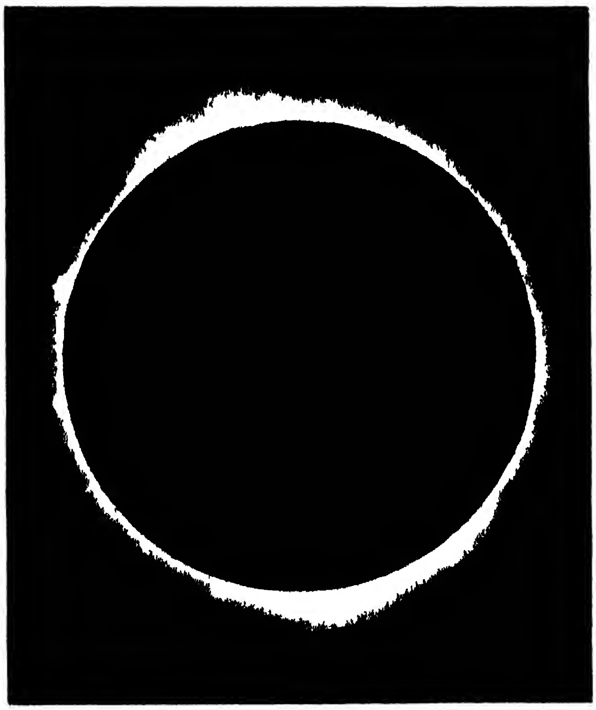
At one time they were only visible during a total eclipse, and at first it was not known whether they were part of the Sun or whether they belonged to the Moon But during the eclipse of 1860 photographs which were taken showed that the Moon's disc moved over the prominences as it passed across the Sun's face, and they were therefore proved to be solar and not lunar

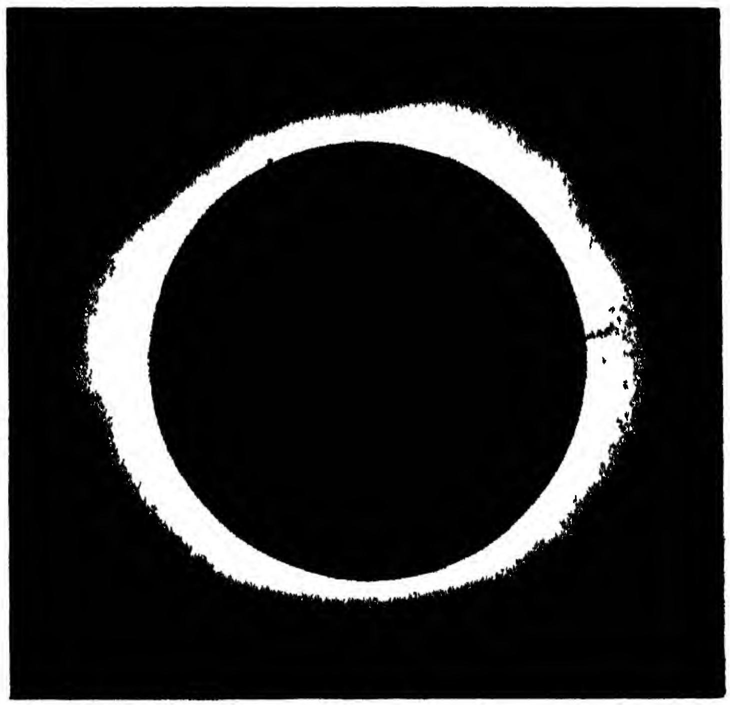
Through the telescope they look like fiery clouds but their real nature only became known when they were examined by the spectroscope in India during the total eclipse of 1868 The spectra taken by various observers showed the lines of hydrogen gas, together with a bright yellow line which these prominences, and by an ingenious device Sir Norman Lockyer, the distinguished English scientist, found a way of examining them with the spectroscope during ordinary daylight, when no eclipse was in progress

There are two distinct kinds of prominences, one kind being known as the quiescent or diffuse prominences, and the other kind as the eruptive or metallic prominences The latter name was given because their spectrum shows the lines which indicate the existence of many metals, in addition to the gases hydrogen, helium and calcium

The quiescent prominences are huge clouds from 50,000 to 100 000 miles in diameter, and equally extensive in their horizontal dimensions

They are not so brilliant as the eruptive prominences and their spectra





The photograph of the solar corona shown on the left was taken at Giggleswick in Yorkshire during the total eclipse of June 29th, 1927, and is published by courtesy of the Royal Astronomical Society The photograph on the right shows the corona seen during the total eclipse of August 31st, 1932, and is given by courtesy of Harvard Observatory, U.S.A

of the corona show that it has a real existence, and that it is a phenomenon of the Sun's atmosphere

The corona it must be explained is not a spherical envelope enclosing the Sun as our atmosphere encloses the Earth The variation in its form at different eclipses proves this At present it cannot be satisfactorily explained and all we can say is that though there is probably incandescent gas and meteoric dust at white heat the corona reminds us more of auroral streamers and the tails of comets than of anything else that we know

But the corona is not the only phenomenon that can be examined during a total eclipse of the Sun The prominences, those wonderful flames of glowing was at first thought to be the metal sodium Closer examination showed that this could not be the case, and so the unknown element which the line represented was called "helium," from the Greek name helios," for the Sun

Of course, scientists at once began to look for this unknown element on the Earth and in 1895 Sir William Ramsay found it while examining the spectrum of a gas extracted from a species of pitchblend

The spectra of the solar prominences also showed the lines of calcium, so that it was known that these prominences consisted of masses of glowing gas made up of hydrogen, helium and calcium

Of course, astronomers wished they had more opportunities of examining generally show the presence of only hydrogen, helium and calcium They do not often change rapidly, and sometimes remain practically unaltered for days together

The eruptive prominences appear only in sunspot zones, and almost always where there are very active sunspots Their spectrum when examined shows the presence of various metals, including magnesium and iron At times the flames become so enormous as to stagger us They have been seen to shoot up to a height of 475,000 miles from the Sun's disc, and their changes are so rapid that to watch them is almost like watching a firework They have been seen to move at the rate of at least 250 miles a second

ECLIPSE AND SUNRISE SEEN ON THE MOON

The drawings above are an artist's impressions, based upon scientific data, of how an eclipse of the sun by the Earth (top) and a sunrise (lower picture) would appear to an observer on the moon. Since the moon has no atmosphere, the sky would seem almost black, and stars would be visible even in broad daylight. As the sun slowly appears over the steep mountains, the chromosphere, with its red flames and streaming silvery corona, would be visible, providing at every lunar dawn much the same magnificent spectacle as would be seen when the sun is blotted out by the interposition of the Earth

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GUNPOWDER TREASON & PLOT

Of all the plots and conspiracies in English history none has seized the popular imagination and roused such a sense of horror and indignation as the Gunpowder Treason and Plot of James the First's reign, when Guy Fawkes and his confederates planned to blow up both Houses of Parliament with their Members and the King and his sons and ministers. Here is the story of the famous plot and its sequel

When James the Scot succeeded Elizabeth the throne was occupied by the meanest and most contemptible monarch that England had ever known, not excepting King John. This son of Mary Queen of Scots was a conceited snob, faithless to friend and foe alike, an arrant hypocrite, ridiculously susceptible to flattery, a miserable coward, a glutton and often a drunkard.

No other proof of his lack of decency is needed than the fact that he kept on friendly terms with Elizabeth after she had cut off his mother's head, simply because he did not want to imperil his succession to the English throne. His behaviour to Sir Walter Raleigh, whom he kept in the Tower for fourteen years and then beheaded, should call forth the execration of all good Englishmen. Even his son Prince Henry remarked: "Only my father would keep such a bird in such a cage."

James's Promise

When Elizabeth died, a deputation of English gentlemen professing the Roman Catholic faith rode north to ask the new King for more lenient treatment of their co-religionists. In the later years of Elizabeth's reign those who followed the old faith had been severely treated. If they were caught meeting for religious observances they were very heavily fined, and these fines became so oppressive as almost to ruin some of the victims.

There is no doubt that James definitely promised the Catholics that they should receive better treatment, although afterwards he strenuously denied this.

After James arrived in London in 1603, some of these Roman Catholics were sent for from various parts of the country to Hampton Court and were assured, with expressions of courtesy and respect, that "It was His Majesty's intention to exonerate the English Catholics from the pecuniary fine of £20 a month for Recusancy imposed by the Statute of Elizabeth, and that they should enjoy this grace and favour so long as they kept themselves upright and civil in all true carriage towards the King and State without contempt." A Recusant was a Catholic who refused to attend the Church of England services, and the name comes from a Latin word meaning "to refuse."

As soon, however, as James felt himself firmly seated on the throne he broke all his promises and began to reimpose the fines on Recusants, making them harder and heavier than even Elizabeth had done. Naturally this breach of faith caused much ill feeling, and it finally reached its climax in the conspiracy which has come down in history as "Gunpowder Treason and Plot."

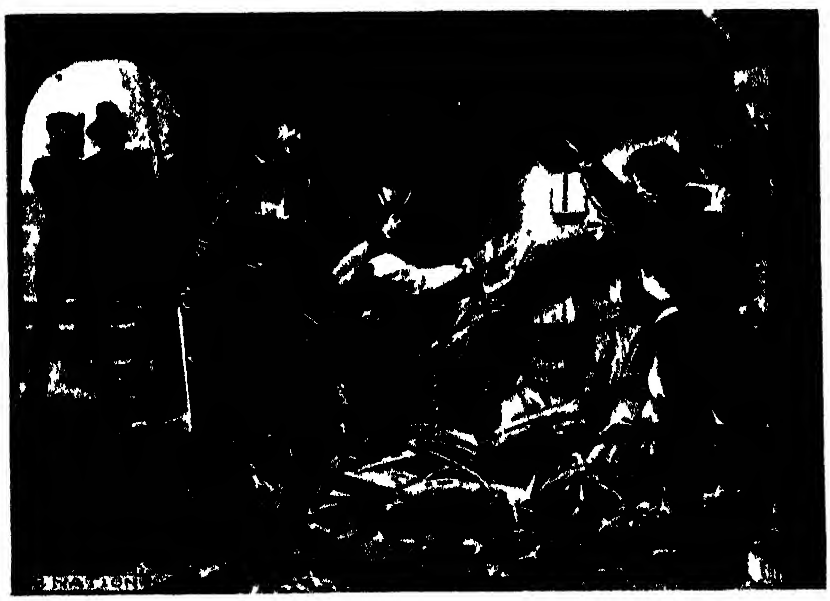
One of the gentlemen who had gone to ask James's leniency for Roman Catholics was Thomas Percy, a relative of the Earl of Northumberland, but it was another gentleman, Robert Catesby, who really originated the conspiracy.

The Gunpowder Plot was undoubtedly the most drastic and dastardly plot that has ever been planned in any country. It might easily have succeeded, and had it done so not only the King but the Prince of Wales, the Duke of York, the whole House of Lords with all the members of the Commons and the entire Government would have been destroyed at one fell blow.

The idea was quite simple. It was to place sufficient gunpowder under the Houses of Parliament to blow the whole structure sky high while the King, surrounded by his ministers, was opening Parliament.

Perhaps the most remarkable thing about the Gunpowder Plot is that nearly all the conspirators, though Roman Catholics by religion, had been brought up in the Protestant faith. Even Guy Fawkes himself was baptised as a Protestant and brought up in his early years in that faith.

It must be distinctly explained that though the object of the conspirators was to place a Roman Catholic sovereign on the English throne, and to restore that faith to its old place as the religion of the nation, Roman Catholics as a whole were no more involved in the Gunpowder Plot, nor sympathetic to it, than were the Protestant subjects of James. The great mass of the Roman Catholics were patriotic Englishmen, who when the plot was disclosed were greatly horrified.



The arrest of Guy Fawkes and the discovery of the gunpowder in the cellar under the Houses of Parliament

Hatching the Plot

Catesby, the author of the plot, had been mixed up in the rebellion of the Earl of Essex in Elizabeth's time, and his life was only saved through the exertions of his friends and the payment of a heavy fine.

The scheme was first disclosed by Catesby to John Wright and Thomas Winter. Catesby informed them that he had "bethought him of a way at one instant to deliver them from all their bonds, and without any foreign help, to replant again the Catholic religion,"

and then he told them that "his plan was to blow up the Parliament House with gunpowder," for, he said, "in that place they have done us all the mischief, and perchance God hath designed that place for their punishment." When Winter seemed startled Catesby replied that "the nature of the disease required so sharp a remedy."

Catesby then suggested that an Englishman named Guido or Guy Fawkes, then in the Netherlands, who was known to be willing to engage in any enterprise for the restoration of the ancient faith, should be brought over to take part in the plot.

Most people think of Guy Fawkes as a kind of uneducated ruffian and desperado, but so far from that being the case, he was a gentleman of good family. His father was a notary of York, and held the office of Registrar and Advocate of the Consistory Court of the Cathedral Church there. Among his schoolfellows at York was Thomas Morton, afterwards Bishop of Durham.

A Man of Great Piety

So far from being a ruffian we are told that Guy was "a man of great piety, of exemplary temperance, of mild and cheerful demeanour, an enemy of broils and disputes, a faithful friend and remarkable for his punctual attendance upon religious observances." His society is said to have been sought by all the most distinguished for nobility and virtue.

He was not, then, as the popular notion suggests, a mercenary assassin taking part in the plot for hire, but an enthusiast whose fanaticism had conquered the better feelings of his nature.

In April, 1604, Winter, who had been sent to summon Fawkes, arrived in London with his companion, and a few days later Thomas Percy was invited to Catesby's lodgings, where he met Thomas Winter, John Wright and Guy Fawkes. As yet he knew nothing of the plot, but when he remarked "Well, gentlemen, shall we always talk and never do anything?" Catesby drew him aside and whispered to him of something that was to be done.

Before disclosing particulars of the scheme, however, Catesby suggested that all of them should take a solemn oath of secrecy, and accordingly a few days later they met once more in another house and took the following oath:

"You shall swear by the blessed Trinity and by the sacrament you now propose to receive never to disclose directly or indirectly, by word or circumstance, the matter that shall be proposed to you, to keep secret, nor desist from the execution thereof until the rest shall give you leave."

The conspirators took the oath upon their knees with their hands laid upon a sacred volume. The plot to blow up the Parliament House was then explained and all expressed their approval.

Catesby had meanwhile made inquiries about a house next door to the Parliament House, which seemed suitable as a base of operations, and this building was taken in Percy's name.

The plan was to mine a passage from the cellar through the wall of the Parliament House and then to place a quantity of gunpowder and other combustibles immediately under the House of Lords. On the fatal day Guy Fawkes was to lay a train to the powder and then escape before the explosion occurred.

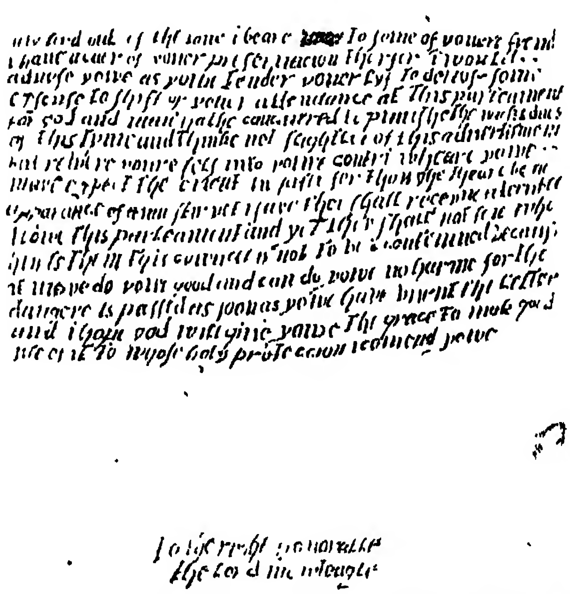
Guy Fawkes was to pose under the name of Johnson as Percy's servant, and he was to have the keys of the house. It was also decided that a house should be taken at Lambeth at which the powder and other combustibles should be collected in small quantities at a time. Later they could be removed by night to the house at Westminster.

Another conspirator was now sworn in, Robert Keyes, and he was to have charge of the house at Lambeth.

Laying in Provisions

When Parliament was adjourned in 1604 the various conspirators decided to go to their homes in the country and to meet again about the beginning of November, but it was December 11th when the confederates assembled and went to the house at Westminster.

The plotters had provided themselves with tools for excavating and had also laid in a good store of hard-boiled eggs, baked meats and pasties, so that suspicion might not be aroused by a constant going to and fro for provisions.



The anonymous letter of warning to Lord Mounteagle that is said to have led to the discovery of Gunpowder Plot

They soon made a way as far as the stone wall which separated the house from the Parliament House, but to mine through this with pickaxes and iron bars was a task harder than they had anticipated. The wall was nine feet thick, and they realised that if the work was to be done by February 7th, the day when Parliament was to meet, more help would be needed. Keyes was therefore sent for from Lambeth, and John Wright's brother Christopher was sworn in.

Fawkes afterwards declared that all who took part in the mining "were gentlemen of name and blood; and not any was employed in or about this action—no, not so much as in digging and mining—that was not a gentleman. And while the others wrought," he said, "I stood as sentinel to descry any man that came near; and when any man came near to the place, upon warning given by me, they ceased, until they had again notice from me to proceed, and we seven lay in the house and had shot and powder, and we all resolved to die in that place before we yielded or were taken."

Plans to Seize all Power

The determined men worked away without rest until Christmas Eve, and during that time not one of them, except Fawkes, was seen by any of the neighbours. Had prominent Roman Catholics been seen going to the house suspicion would have been aroused that they were attending religious services there, and the place would have been examined.

The idea of the conspirators was that after the Parliament House was blown up with all its occupants, James's daughter Elizabeth, who was staying at a house near Coventry, should be seized, proclaimed as Queen and henceforth brought up in the old faith. There was also to be a rendezvous in Warwickshire where supplies of horses and arms would be ready to start an insurrection and seize all power.

Almost from the first there seem to have been qualms of conscience or family feeling about blowing up the innocent with what were regarded as the guilty, and some of the conspirators wanted to give warning to their relatives who would be present, so that they might escape the general holocaust.

While they were discussing these matters the meeting of Parliament was put off from February 7th to October 3rd following. The conspirators were glad, for they now had abundance of time to mature their plans and add to their numbers. They at once decided to separate till after the Christmas holidays, and then to meet again and renew their mining operations. In order to avert suspicion they were to see little or nothing of one another during the interval.

In January two more were added to the number of conspirators, John Grant and Robert Winter, they previously having taken the oath of secrecy in the presence of Catesby and Thomas Winter. Robert Winter was the elder brother of Thomas.

About this time, too, an old servant of Catesby, Thomas Bates, seemed to show by his behaviour that he had some suspicion, and so it was decided to bind him by the oath of secrecy, to ensure that he should not disclose anything. He was really the only man among the plotters who was of mean station.

In February the conspirators resumed their work at Westminster, and by almost superhuman exertions pierced half way through the stone wall. Percy and Catesby, who were unusually tall men, found it very fatiguing to work day and night in a stooping position in the mine.

A Sudden Alarm

One morning while they were at work they suddenly heard a rushing noise in a cellar nearly above their heads. At first they thought they were discovered, but Fawkes, who was sent to reconnoitre, found that one Bright, to whom the cellar belonged, was selling off his coals in order to move to another part, and it was the noise of the shovelling of the coals that they had heard. Fawkes noticed that the place was a large vault situated immediately underneath the House of Lords, the very place they needed for their purpose.

The difficulties of carrying the mine through the nine foot wall were more and more being realised. The conspirators feared that the heavy blows necessary to break up the stone would be heard. At any moment water might flow through from the Thames, and submerge them, and every night the material that had been mined had to be carried out and spread in the garden.

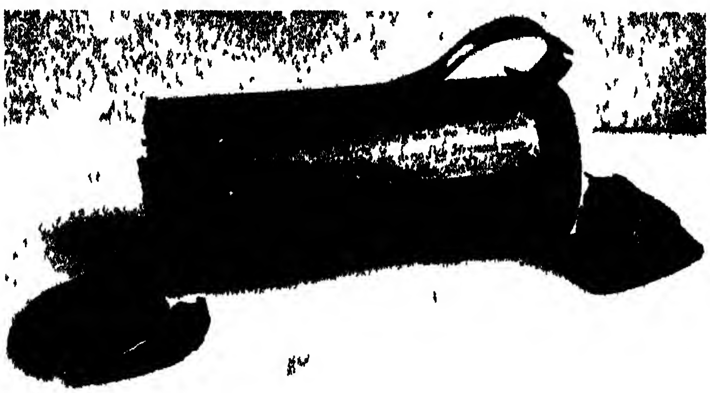
After some discussion it was decided that the vacant cellar should be hired in Percy's name, it being explained that he needed a cellar in which to keep his wood and coal. As soon as possession was obtained the mine was abandoned and then twenty barrels of powder, which had been collected at Lambeth, were brought across the river by night and placed in the cellar.

Large stones and the iron bars and other tools used in mining were thrown among the barrels, as Guy Fawkes afterwards declared, "to make the breach the greater," and the whole was then covered with faggots and billets of wood. To complete the deception a quantity of lumber and a number of empty bottles were also placed in the cellar, as though it were a dumping-ground for rubbish.

By May 1605 everything was ready. Altogether about 36 casks containing two tons of gunpowder had been placed in position in the cellar. The entrance was then closed, but certain marks were put on the door inside by which the conspirators might know whether any one had entered in their absence.

Nearly five months must elapse before the meeting of Parliament, and so that no suspicion might be aroused through their being seen together the plotters decided to separate.

Guy Fawkes was despatched to Flanders to consult with one or two likely sympathisers among the English refugees, and soon after his return Parliament was further prorogued from October 3rd to November 5th. The conspirators were alarmed, for they feared that these repeated prorogations indicated the discovery of their plot. Careful observation, however, did not confirm these fears, and the suspicions were allayed.


The actual dark lantern found on Guy Fawkes which is now preserved in the Bodleian Library at Oxford

Catesby had always realised the importance, should the blowing up of the Houses of Parliament prove successful, of having a military force ready to put down any resistance in the country. Horses, arms, powder and other munitions were therefore purchased and distributed in the houses of the various conspirators in the Midland Counties.

The Need for Money

At Michaelmas Percy and Catesby met by appointment at Bath and they decided that it was necessary to add two or three persons of wealth to the conspiracy in order that further money might be provided for gathering supplies.

After the usual oath of secrecy, therefore, Sir Everard Digby, Ambrose Rookwood and Francis Tresham, the latter being a near relation of Catesby, were informed of the plot.

By the way, it is interesting to remember that Rookwood rented Clopton House near Stratford-on-Avon, to which, it is said, Shakespeare often used to walk out for the purpose of reading and studying books in the library there. Shakespeare used Clopton House as the original of Petruchio's country house where some of the scenes in "The Taming of the Shrew" are laid.

Did Shakespeare ever suspect what was going on? He was living in Stratford at the time. It would be interesting to know what he said and thought when he learnt that his neighbour at the Manor House was mixed up in the terrible plot and later when the news came that he had been hanged as a traitor.

Rookwood was very far from being as callous as some of the other conspirators, for we are told that he expressed scruples of conscience respecting the lawfulness of the action.

By bringing his kinsman Francis Tresham into the secret Catesby made his great blunder. But Tresham's money was needed and he agreed to furnish £2,000 towards the scheme. But from the first his sincerity seems to have been suspected by the other conspirators, and Catesby soon repented that he had admitted Tresham into the conspiracy at all. Indeed from the advent of Tresham we learn that Catesby had fearful forebodings and ominous dreams, portending failure.

Final Details

As the meeting of Parliament was now approaching the final details of the plot were arranged. It was decided that Guy Fawkes, as a man of approved courage and of experience in emergencies, should be entrusted with firing the gunpowder. He was to do this by means of a slow burning match, which would allow him a quarter of an hour for his escape before the explosion took place. He was at once to embark on a vessel in the river and proceed to Flanders, with the news of what had happened.

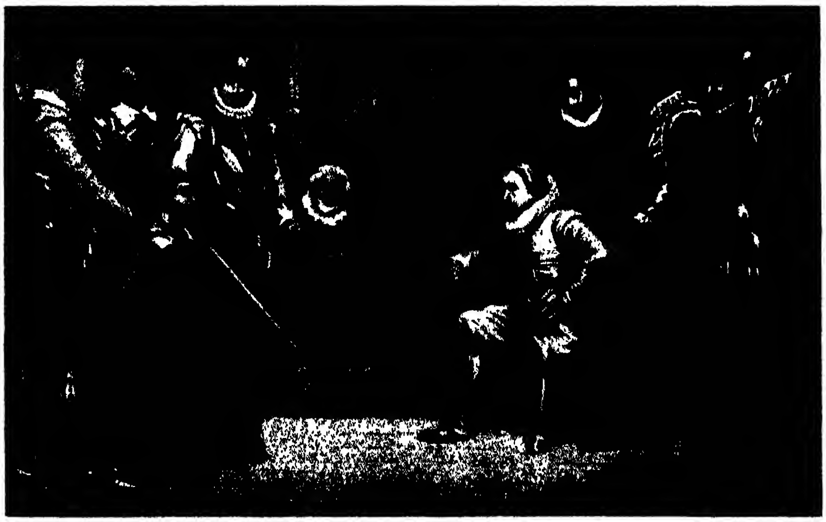
Sir Everard Digby was to assemble a number of sympathetic gentlemen on November 5th at Dunchurch in Warwickshire under the pretence of hunting, and as soon as they received notice that the blow in London had been struck they were to seize the Princess Elizabeth and proclaim her Queen. Then they were to obtain horses from Warwick Castle and armour from another mansion, "and by that time," said Catesby, "I hope some friends will come and take our parts."

If Henry Prince of Wales or Charles Duke of York were not in the Parliament House with the King, Percy was to seize them and carry them with all speed to Dunchurch.

But now the question again arose as to which, if any, of the peers who professed the old faith were to be

saved from destruction. Most of the conspirators had relatives whom they were very anxious should be warned to stop away. But Catesby emphasised the danger of any such warnings, and was all for allowing the innocent to be blown up with the guilty in what he considered the good cause.

Tresham, however, was very insistent and passionately requested that warning should be given at least to Lord Mounteagle. There was something of a squabble, and Tresham hinted that the money he had promised could not be found at once, and it would be better to defer the execution of the plot till the closing of Parliament.



Guy Fawkes being examined before King James I on the night of his arrest
From the drawing by J. McL. Ralston

He seems to have taken no further part in the consultations of the conspirators, and when later on they fled to the country he remained in London and made no secret of his presence there. This is significant, in view of what happened afterwards, as we shall see.

A Fatal Supper

On October 26th, ten days before the meeting of Parliament, Lord Mounteagle quite unexpectedly announced that he was giving a supper at his mansion in Hoxton. There was no apparent reason for such a gathering and he had not been at the house for at least a month before.

About seven o'clock, while all the guests were at table, a letter was brought in to him by a page, who said he had received it that same evening from a man in the street, whose features he could not distinguish. Lord Mounteagle opened the letter and handing it to a gentleman in his service rather ostentatiously asked him to read it aloud. This is the letter, with the spelling modernised and punctuation added:

"My lord, out of the love I bear to some of your friends I have a care of your preservation. Therefore I would advise you, as you tender your life, to devise some excuse to shift of your attendance at this Parliament, for God and man hath concurred to punish the wickedness of this time; and think not slightly of this advertisement, but retire yourself into your country, where you may expect the event in safety. For though there be no appearance of any stir, yet I say they shall receive a terrible blow, this Parliament, and yet they shall not see who hurts them. This counsel is not to be condemned because it may do you good, and can do you no harm, for the danger is passed as soon as you have burnt the letter, and I hope God will give you the grace to make good use of it. To Whose holy protection I commend you."

Who wrote the letter? Nobody can say for certain, but there seems every likelihood that it emanated from Francis Tresham, though it was not in his handwriting. Mounteagle was his brother-in-law, and we learn that he was "exceeding earnest" that this peer and another, who was also his brother-in-law, Lord Stourton, should absent themselves from Parliament.

It is more than likely, however, that he had done more than inspire an anonymous letter, and it is probable that he had actually disclosed the plot some time before, and that the letter was only a blind to conceal his treachery and give an opportunity for a plausible story for public consumption.

However, whether that be so or not, Lord Mounteagle took the letter that same evening to the Earl of Salisbury at Whitehall, and as soon as the Earl had read the letter he told Mounteagle that "he had done like a discreet nobleman not to conceal a matter of such a nature whatever the consequence might prove."

Treachery Firmly Denied

News of the delivery of the letter to Mounteagle and its disclosure by him to the Secretary of State, Lord Salisbury, reached Thomas Winter, and the news was at once conveyed to Catesby. They became greatly alarmed, but before telling the other conspirators decided to make inquiries as to whether the plot was actually discovered. Should their worst fears be confirmed they would warn their confederates so that all might take flight.

They at once suspected Tresham, though he had been absent in Northamptonshire for at least a week. He returned to London on October 30th, and Catesby and Winter charged him with having written the letter. They had previously decided that if he confessed the fact or confirmed their suspicions by his behaviour, they would stab him on the spot. But he denied the charge with such firmness and so many solemn oaths that although they still doubted his sincerity they hesitated to kill him.

Catesby sent Guy Fawkes to the cellar without telling him of the danger he ran. He was told to observe whether the private marks placed inside had been disturbed. Accordingly he went, examined the cellar carefully, found everything as he had left it, and returning gave Catesby and Winter his report.

Warning to Fly

This rather reassured them, but when on Sunday, November 3rd, they learnt that the letter to Lord Mounteagle had been shown to the King, who attached great importance to it, they were troubled exceedingly. They therefore determined to have another interview with Tresham, and we are told that when this took place Tresham spoke like a frantic man, declaring that to his certain knowledge the whole Plot was discovered, and that they were all lost men unless they saved themselves by instant flight.

Nevertheless, owing to some unaccountable infatuation, the conspirators decided to see what happened on the following day. It was arranged that Catesby, John Wright and Digby should leave London on the following afternoon. Fawkes, with the courage which he had shown right through, took up his station in the cellar.

On the afternoon of November 4th the Lord Chamberlain and Lord Mounteagle visited the cellar on some pretext and asked casually to whom the large quantity of fuel stored there belonged. On learning that it was Percy's, they went away.

Fawkes was alarmed, and went and told Percy, but returned to his dangerous post, determined, as he afterwards declared, to blow up the House on the first appearance of danger, and so to perish together with those who might come to apprehend him.

Just before midnight, on the eve of November 5th, Sir Thomas Knevet, a Westminster magistrate, with a number of assistants, went secretly and suddenly to the House. Just as they arrived Guy Fawkes was stepping out of the door. He was detained, while Knevet examined the cellar. Under the billets of wood were found 36

barrels of powder, and Fawkes was then seized, bound hand and foot, and searched. On him were found a watch, slow matches and touchwood, together with a dark lantern, which, by the way, is now in the Bodleian Library at Oxford.

He at once confessed, and Knevet, leaving the prisoner in charge of a guard, hurried off to the Earl of Salisbury.

The Privy Council was summoned to meet in the King's bedchamber, and Fawkes was brought before it and questioned. As Lord Salisbury said afterwards, "He was no more dismayed than if he had been taken for a poor robbery on the highway." He declared that his name was John Johnson, and that he was a servant of Thomas Percy, and that if he had not been taken that night he would have blown up the Upper House when the King, lords, bishops and others were there.

To Blow the Scots to Scotland

When the King asked him how he could conspire against his children and so many innocent souls, Fawkes answered, "Dangerous diseases require a dangerous remedy." And when questioned by some of the Scottish courtiers he told them fiercely that one of his objects was "to blow the Scots back again into Scotland." This was a home thrust, for when James came from Scotland he brought with him a whole horde of hungry Scots who were now living on the fat of the land.

Guy Fawkes would not disclose the names of the other conspirators, and he was sent under strict guard to the Tower of London.

Meanwhile, the other conspirators had travelled into the Midlands and gathered at Holbeach, a house on the borders of Staffordshire. The Roman Catholic gentry all round would have nothing whatever to do with the plot, and the common people were quite indifferent. They decided, therefore, to make a stand at Holbeach and sell their lives dearly. Sir Everard Digby forsook his fellow conspirators and went away, but he was soon after captured and taken to London.

The Last Desperate Stand

While the plotters were waiting for the arrival of the Sheriff of Worcestershire with an armed force to take them, an accident happened which they looked upon as a bad omen. A plate with some gunpowder was drying over a large fire when a live coal shot into it and the whole blew up with a tremendous explosion.

Curiously enough, a large bag of gunpowder close by was carried by the explosion through the roof, without being ignited. If this had gone off the house would have been blown up and all the conspirators destroyed. As it was, several of them, including Catesby, were severely burned. The incident shook their confidence and they began to believe that Providence was against them.

Robert Winter now ran away, and also Thomas Bates, Catesby's servant. The sheriff's force arrived, and the assault was begun. Almost at the beginning the two Wrights and Catesby and Percy were killed. Rookwood was badly wounded, and soon all were overpowered.

The remaining conspirators were arrested shortly afterwards, and all were sent to London. Although Guy Fawkes, under examination, had mentioned Tresham as being in the plot, that conspirator was not arrested till November 15th, and although he was sent to the Tower he was treated with great consideration, and his wife and servant were allowed to be with him.

Guy Fawkes Confesses

But on December 23rd he died, and the explanation given was that he had been suffering from a dangerous and painful disease, which gradually became worse till he passed away. It is believed by some that he was conveniently poisoned, so that he might not say too much about Lord Mounteagle, who had been involved in a previous conspiracy, but had re-established his loyalty by disclosing the Gunpowder Plot.

A full confession was extorted from Guy Fawkes by cruel torture, but all through he showed himself full of courage. He and the other surviving plotters were duly tried and found guilty of treason, and all were executed.

The End of the Conspirators

Of the original thirteen only eight had survived. Digby, Robert Winter, Grant and Bates were drawn on sledges and hurdles to a scaffold in St Paul's Churchyard, and were there executed. The next day Thomas Winter, Rookwood, Keyes and Guy Fawkes were drawn from the Tower to Old Palace Yard at Westminster, opposite the Parliament House, where they also were executed.

It is difficult for us to realise in these days how the daring and comprehensiveness of the plot stirred England and indeed all Europe. Men everywhere of all faiths were horrified, and for centuries Gunpowder Treason and Plot has been remembered, and the deliverance of the King and Parliament celebrated by the lighting of bonfires, the burning of "guys," and the letting off of fireworks.

The last stand of the Gunpowder Plot conspirators at Holbeach House in Staffordshire. From the painting by Ernest Crofts, A.R.A.

A PETRIFIED FOREST OF THE FAR DISTANT PAST

One of the most interesting relics of a distant geological age is the petrified forest of Arizona, where, lying about on the surface of the ground, are to be seen the fossilised trunks of giant trees. For thousands of years these were buried and were gradually changed into stone, thereby being preserved for our inspection. Here is one trunk forming a natural bridge

After these trees had been buried for generations and had become fossilised, the land was upheaved, and the wind and water, assisted by the action of rivers, wore away the soil till the petrified trees were left open to the sky. They now tell the story of their past

THE PETRIFIED FORESTS OF THE PAST

We know a great deal about the vegetation of past ages by the examination of fossilised remains of plants that have been preserved for us in the coal measures and elsewhere. In some parts of America the fossilised remains of tree trunks are found lying about on the surface of the ground, and the interesting story of how these came to be there is told on this page

In various parts of America there are what are known as "petrified forests" where are found the fossilised trunks and branches of trees which grew in long distant ages when the mastodon roamed the earth and the horse had not yet been evolved from the little three-toed animal known as the protohippus.

Of course, in England we sometimes come across the trunks of trees of the Carboniferous period standing upright in the coal seams, but in America the strange thing is that over large areas the fossilised tree trunks, some of them of huge size, are found lying about on the surface of the earth.

It is interesting to know how they came there, and the first thing we learn about them is that they are evidence of a changed climate. In the hot arid regions of Arizona there are many of these fossilised trees lying about in regions where, owing to the dryness, little or nothing will grow except cacti. Yet it is evident from the existence of these trees that at one time the climate of Arizona was humid, and that plenty of rain fell there.

What happened is that here, stretching over many square miles, was a vast and flourishing forest, but in some way it became covered with water and then mud and gravel were slowly deposited until the whole forest was covered. The pressure from above squeezed the mud and gravel into rock, and then, owing to some upheaval, the land once again was raised above the level of the water. The reverse process then began, and owing to weathering, that is the action of wind and rain and river, the rock was gradually broken up and worn away till thousands of these fossilised tree trunks were once more exposed to the light of the sky

Dispersing a Forest

Often the water carried them away to a distance, from where they had originally been buried and so we find the fossil trees not only on the actual site of the forest, but many miles away from it No doubt beneath the surface there are thousands of other fossilised trees yet waiting to be exposed. Some of the trees are quite well preserved.

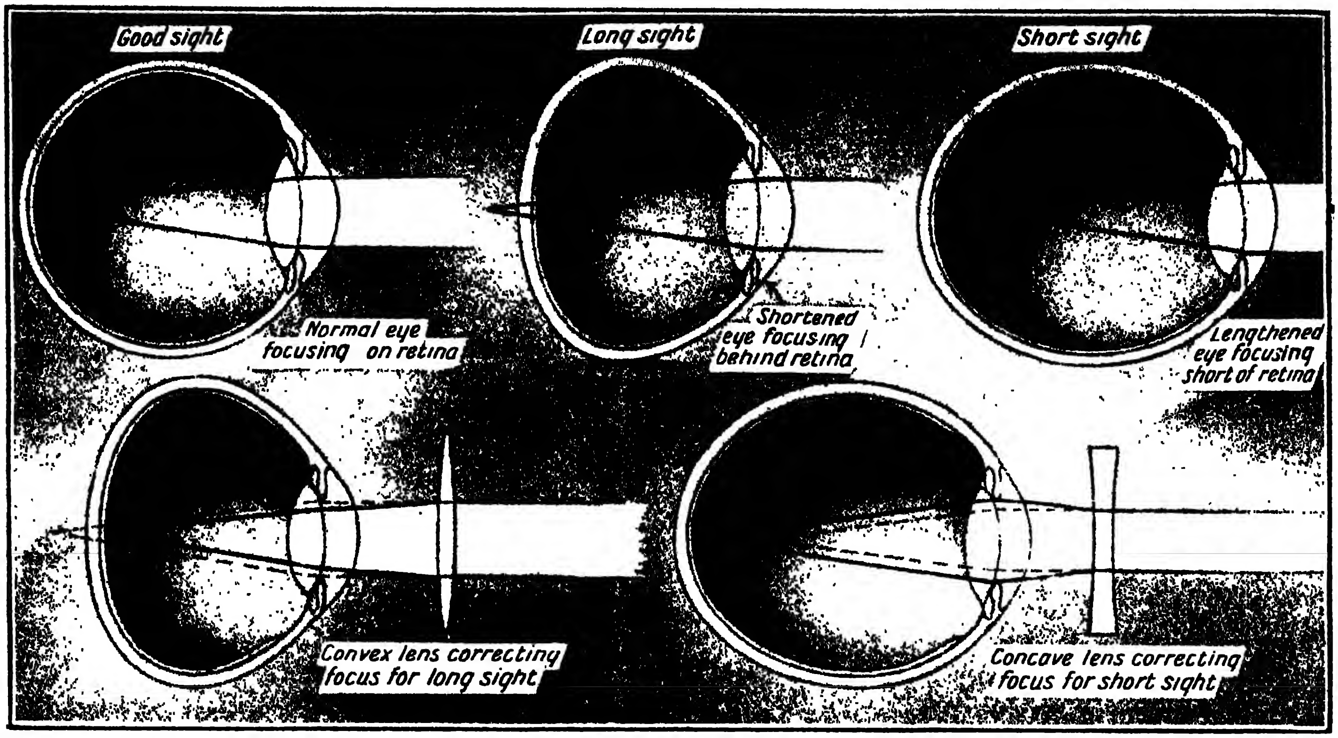
The trunks measure from 150 to 200 feet in length, and from 6 to 14 feet in circumference. The roots of many of them are also exposed to view. In one case a large fossilised tree-trunk lies across a canyon, forming a natural bridge on which men cross the chasm. The trunk is in an excellent state of preservation, and though the roots are not there we see the places where they joined the trunk.

These trees flourished millions of years ago. They were cone-bearing trees and in some cases we find the fossilised cones. Similar fossilised trees are found in the Yellowstone Park and other regions of Western America, though not so many of them as in Arizona. It is not only in America, however, that forests have been submerged; the same thing has happened in Europe and even in England.

Round our coasts at various points there are old land surfaces which are wholly or partly submerged, and which contain the stumps of trees Sometimes these are erect with their roots buried in the old soil in which they flourished. Of course, all these submerged forests are not of the same age; some date back thousands of years before the others. Submerged forests have been found near Sharpness in Gloucester, in Cardigan Bay, St. Bride's Bay, and Swansea Bay, near the mouth of the river Parret, and off the coasts of Devon and Somerset. Also there are peat-beds in which tree-stumps are standing just where they grew

The fossilised remains of giant tree trunks lying on the surface of the ground in the dry region of Arizona, U.S.A.

WHY SOME PEOPLE HAVE TO WEAR SPECTACLES



In these pictures we see why some people have to wear spectacles and why with the lenses in front of their eyes they can see clearly. When the sight is good the rays of light entering the pupil are focused exactly upon the retina, or curtain, at the back of the eye and a clear image results. When a person is long-sighted it is due to the shortening of the eyeball, with the result that the rays, instead of being focused on the retina, have their focus behind it and no clear image is thus formed. On the other hand, a short-sighted person has the eyeball lengthened, and the rays are focused before they reach the retina, also with the result that no clear image is formed on the retina. The bottom pictures show how convex and concave lenses, by bending the rays of light, focus them at the right point

THE VALUABLE EGG OF AN EXTINCT BIRD

In the year 1844 the last known living specimens of the great auk or gare-fowl were captured off Iceland. It is a thousand pities that this happened, for the bird, which was a relation of the guillemots and puffins, was a very interesting creature.

It was the only bird found in the northern hemisphere which was unable to fly. We know that in the southern hemisphere there are penguins of various species and that the wings of these are mere flappers which are no use at all for flight. The wings of the great auk were of a similar character, and resembled those of the penguin in general appearance.

This curious and interesting bird was about the size of a goose, and while it was white beneath, its head and back were covered with black plumage. Its legs were placed very far back under its body, and so it had the curious appearance of sitting on its tail when really it was resting on its legs.

At one time it was quite a common bird, and was found from the Bay of Biscay right up to Greenland. The greatest numbers lived on the rocky islands near Iceland and off Newfoundland.

Of course, like the penguin, the bird was quite helpless against human enemies when found on land, and as its feathers were in great demand it was killed in large numbers, so that in a few years it became extinct.

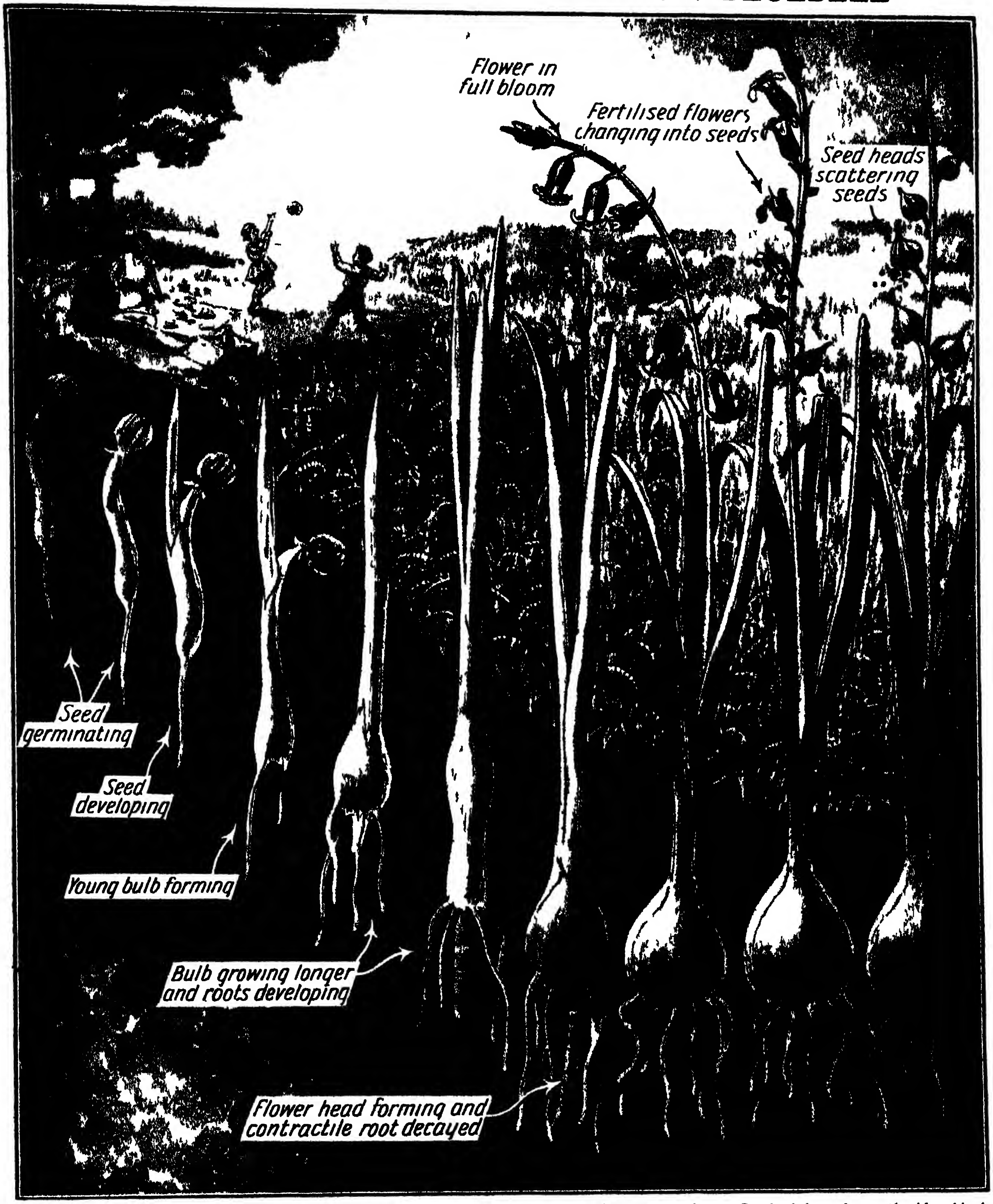
This specimen of the egg of the great auk, a bird now extinct, was sold by auction and realised 315 guineas. Only seventy specimens of the great auk's egg are known in the world

Very few specimens of stuffed great auks appear in museums to-day, and there are also very few eggs. There are believed to be 22 specimens of the bird in Great Britain, and only about 70 examples of the eggs are known throughout the world. When one of these eggs is put up for sale in the auction room the bidding is very keen and the price realised is always large. Even a damaged specimen will fetch more than £100, and a good specimen has been sold for 315 guineas.

The great auk was found in Great Britain, having been recorded in the Outer Hebrides since 1684, but it had become rare as a British bird by the beginning of the nineteenth century.

The eggs of the great auk resemble those of the razorbill in general coloration, that is, they are pear-shaped and whitish or pale brown, blotched or spotted with dark reddish-brown and black. Some of them exhibit a green tinge. The great auk lived chiefly on fish, and it was a very powerful swimmer and diver, using its small wings to paddle it along swiftly under water. Its note was a low croak.

THE LIFE-STORY OF THE COMMON BLUEBELL



On this page we see the life-story of the common bluebell or wild hyacinth from seed to mature plant On the left is shown the blue-black seed of the plant germinating among the dead leaves on the surface of the ground where it has fallen from its parent plant The root grows downward and then a slit appears in the cotyledon or leaf part of the embryo and from it grows the first green leaf The tip of the cotyledon sucks food from the embryo and this accumulates at the base of the cotyledon, swells, and forms a small bulb Leaves now form and grow up while the bulb increases in size and descends by growing longer and putting out roots The largest root, known as a contractile root, helps the bulb to descend and then decays, leaving a scar on the bulb The leaves develop and a flower stem rises on which buds form, that open into flowers, and when these are fertilised they develop into seed-heads which burst and scatter the seeds

AN ANIMAL THAT LEARNT BY EXPERIENCE

The American bison has a strangely shaped but impressive head. The long black hair on the back of the head and neck give an impression of greater size than the animal really possesses. The bison has often been regarded as stupid because in early days herds used to allow themselves to be shot down without attempting to escape. But the animal was not so stupid, after all, for in course of time it learnt to fear man, and when a man was sighted, even two miles away, the bison herd would run, not for one or two miles, but for seven or eight miles. Above we see a bull. On page 239 is a cow bison and a calf

WONDERS of ANIMAL & PLANT LIFE

THE DESTRUCTIVE DEATH-WATCH BEETLE

The death-watch beetle is a terrible pest, and has ruined many a fine timbered roof. Hundreds of thousands of pounds have had to be spent in fighting the insect and repairing the damage done by it. The grub or larva which does a great part of the boring is armed with minute horny pegs, directed out and backward, with which it presses upon the sides and top of the bore-hole, and thus obtains great driving power for its destructive jaws. Here we read the story of the death-watch beetle.

THE insects are the greatest foes of man on the Earth to-day. They spread disease and destroy human lives by thousands; they devour the food supplies of man and animal; and they prey upon the woodwork of his buildings, wrecking many a home and damaging many a stately fane.

During the past few years hundreds of thousands of pounds have had to be expended in England alone in restoring the damage done in cathedrals and public buildings and old mansions by the death-watch beetle.

This tiny enemy, little more than a quarter of an inch in length and dark brown in colour, carries on its fell work out of sight of man, who only knows of its existence by the curious ticking sound which it makes, and which has given it its popular name.

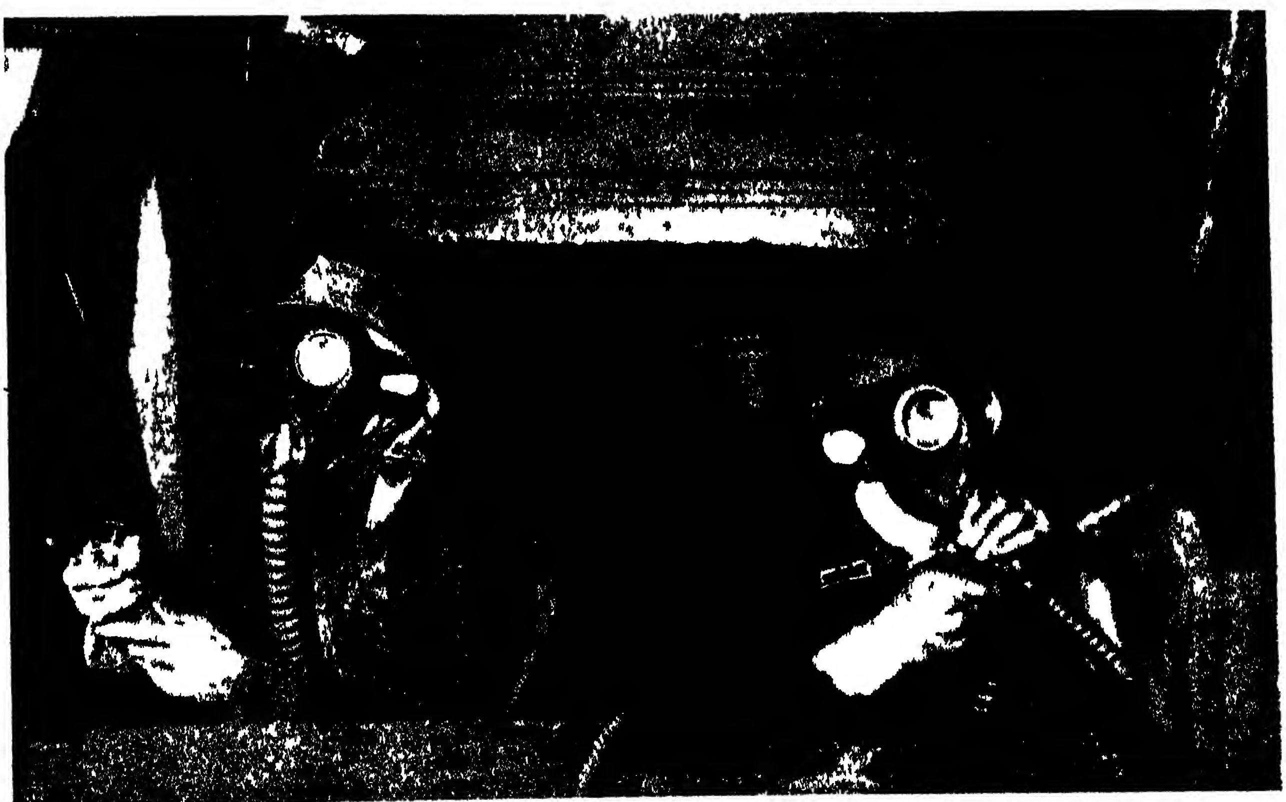
The death-watch beetle goes through the various stages of life common to insects of its kind. As a beetle it emerges some time between April and June from decaying oak trees in the open air or from the oak or chestnut timbers of ancient buildings.

Then the male beetle seeks a mate, and this it does by the curious tapping sound which in the old days of superstition caused so much fear. It was the mystery of the unseen and unexplained sound that made people think there was something supernatural about it. Probably on more than one occasion some prominent person did actually die after the ticking sound was heard. It would be strange, with people dying every hour, if there were not a coincidence of this kind every now and then.

The death-watch beetle boring into a beam

The beetle makes its rhythmic tapping by raising upon its front legs and jerking its body forward seven or eight times in rapid succession, striking each time a sharp blow upon the surface of the wood with the front part of its head.

It gives eight taps in rather less than a second, and the moment it stops, if there is another beetle within hearing, this will reply by tapping back in the same manner. It is clear from this that the death-watch beetle can hear, though where its organs of hearing are situated is not known with any



This photograph shows how the fight with the death-watch beetle is carried on. Men wearing gas-masks are spraying a poisonous chemical upon damaged timbers in a church belfry. The beetle in the upper picture has been very much enlarged

certainty. They are believed to be in the antennae or feelers.

The beetle will go on tapping for a very long time. Dr. Charles Gahan, Keeper of the Department of Entomology at the British Museum, tells us that a female that was captured a few years ago was placed in a small box, where it continued to live for ten weeks, and at almost any moment throughout the whole of that time it was ready to respond by tapping its head against the bottom and sides of the box, to a sound made by tapping at the same rate with a pencil or anything within a few yards of its prison.

After pairing the female beetle lays about 80 white oval eggs in cracks and crevices, and also on open surfaces of old wood.

Feeding on Wood

Then a few weeks later the parent beetles die, but from the eggs there hatch out little whitish grubs that seek a tiny crack in the timber in which they commence boring. All that summer and during two more they feed on the wood, honeycombing the timber with tunnels. When full-grown the grubs are about half an inch in length.

Then late in the third summer they tunnel towards the outside of the wood, and when very near the surface change into the chrysalis or pupa stage. From that stage during the same autumn the beetles develop, and gnaw their way out of the wood in the next spring. If, however, the building is artificially warmed, they come out earlier.

The beetles have wings and are able to fly, and in one church they were very abundant and became a nuisance to worshippers as they flew about.

Sometimes they attack furniture, such as old oak bookcases. While in the ordinary way they do not attack any timber but oak and chestnut, a piece of Scots pinewood from an old City church in London was found completely riddled with the holes of the death-watch beetle, so that it would seem that the insect will attack even this kind of wood if it has lost all its resinous matter.

In recent years widespread alarm has been aroused by the discovery of the ravages of the death-watch beetle in many of our finest cathedrals and other buildings. Many thousands of pounds had to be spent in restoring the roof of Westminster Hall.

Working in the Dark

The grub's habit of working in the dark and not coming outside the timber until completely transformed into the perfect beetle often causes beams whose interior is actually eaten away to have a sound appearance. The ravages of the beetle are found especially in ill-ventilated places.

The method of fighting the beetle which has obtained a good deal of success is to spray a liquid made up of soap, wax, cedar wood oil, and two powerful chemicals, so that the timber becomes thoroughly wetted and the fluid penetrates all beetle holes and decayed parts. It there gives off a vapour that destroys the grubs and leaves behind an invisible film of poison which kills beetles seeking to enter.

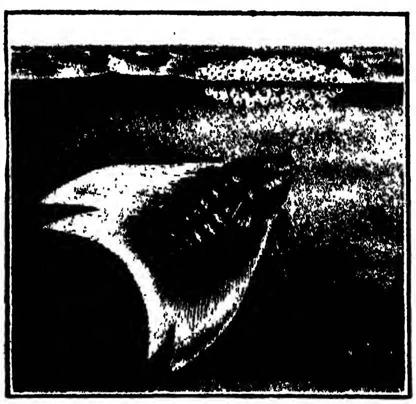
An oak beam in a London church which has been badly damaged by the death-watch beetle's ravages, and parts of which will have to be replaced by new timber, while the rest will be sprayed with poison

THE STRANGE NESTS THAT SOME FISHES MAKE

Many of the fishes build nests, in which to deposit their spawn or eggs. One of these is the paradise fish of Siam, an interesting creature which is kept by the Siamese in glass jars, and fed upon the larvae of mosquitoes. It is trained to fight for the amusement of its owners.

This fish, when it builds its nest, does not use materials like weed or sand. The male rises to the surface and, sucking in a quantity of air, carries this down, later ejecting it as a mucous-covered bubble. The operation is performed again and again, until there is quite a large mass of film-like bubbles floating at the surface of the water. In it the female deposits her eggs, and the young, when they hatch out, feed upon the bubble coverings.

The lamprey builds a very different kind of nest. A place is cleared in a river bed, and then stones are deposited till a pile is formed. Quite large stones are carried to the nest by two of the lampreys joining forces, as shown in the picture. The pile is sometimes two or three feet high and four feet in diameter. Sometimes as many as fifty lampreys will join in building a common nest which then assumes the proportions of a dam. One such has been seen 15 feet long and 3 feet high.



The paradise fish making its bubble nest

A pair of lampreys building their stone nest

EXPERIMENTS ILLUSTRATING THE WAYS OF HEAT

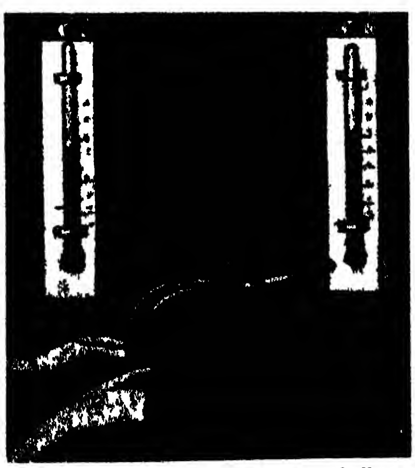
There are many interesting experiments which we can perform at home to illustrate the properties of heat, and some of the more entertaining of these are illustrated here.

Heat is, of course, obtained from the Sun as well as from fires on the Earth

Burning a string without fire

and this we can prove quite easily by means of a burning glass that is of any magnifying lens such as a reading glass. We take a small ring or button and suspend this inside a bottle by means of a cotton thread fastened to the cork.

Now we tell our friends that we will divide the cord and let the button fall to the bottom of the bottle without touching button, cord or bottle. This seems impossible, but the feat is quite easily performed by concentrating the Sun's rays upon the thread by means of a magnifying glass, as shown in the picture. Of course, we must choose a warm sunny day for the experiment.



Blowing on a thermometer with bellows

Another kind of experiment can be carried out with no other apparatus than a thermometer and a pair of bellows. Get someone to blow with the bellows upon your hand; you will feel cool as a result. We might think therefore, quite naturally, that if we blow vigorously upon the bulb of the thermometer with the bellows the result will be to lower the temperature and send the mercury down. The result, however, is the opposite; the mercury rises, and the reason is that the energy of the vigorous blowing raises the temperature of the air.

Substances expand as they are heated and we can prove this by an

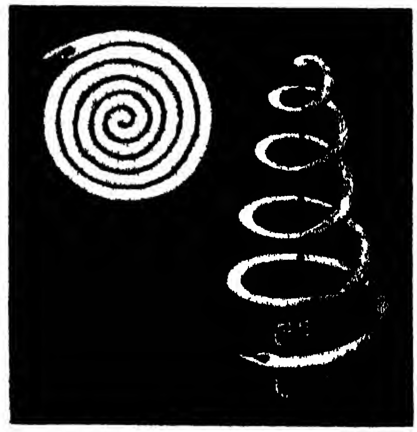
A proof that metal expands when heated

interesting experiment. We cut a cork to the shape shown in the third picture, that is with a flat face scalloped out in the middle. We then cut a step at one end and stick a needle into the cork so that it will lie across the semicircular opening with its head and eye on the step. Now stick a second needle in an upright position into the cork, with its point through

Boiling water in a paper bag

the eye of the prostrate needle. If the horizontal needle is now held in the flame of a candle, it will expand and push the upright needle over at an angle, as shown in the picture.

We can boil water in a paper vessel, although this may seem to some an impossible feat to perform. Twist a piece of iron wire into a spiral and bend the other end into a loop as shown in the picture. Now fit the spiral over a candle and on the loop place a disc of stout white paper about twice the diameter of the loop. Push the paper down in the middle to form a kind of bowl and fill it with water. Then light



The whirling serpent

the candle. The paper will not burn and before long the water will boil.

Take a piece of cardboard and draw on it a spiral with a serpent's head at the end. Then cut this out and support the end of the tail lightly on the point of a needle stuck in a cork. If this be placed on a mantelpiece over a fire or gas stove the serpent will revolve, being driven round by the upward current of warm air.

As a final experiment, take an ordinary penholder with a metal end and fix round it a piece of paper, partly on the metal and partly on the wood. Hold it over the flame of a lamp or candle. The paper will be

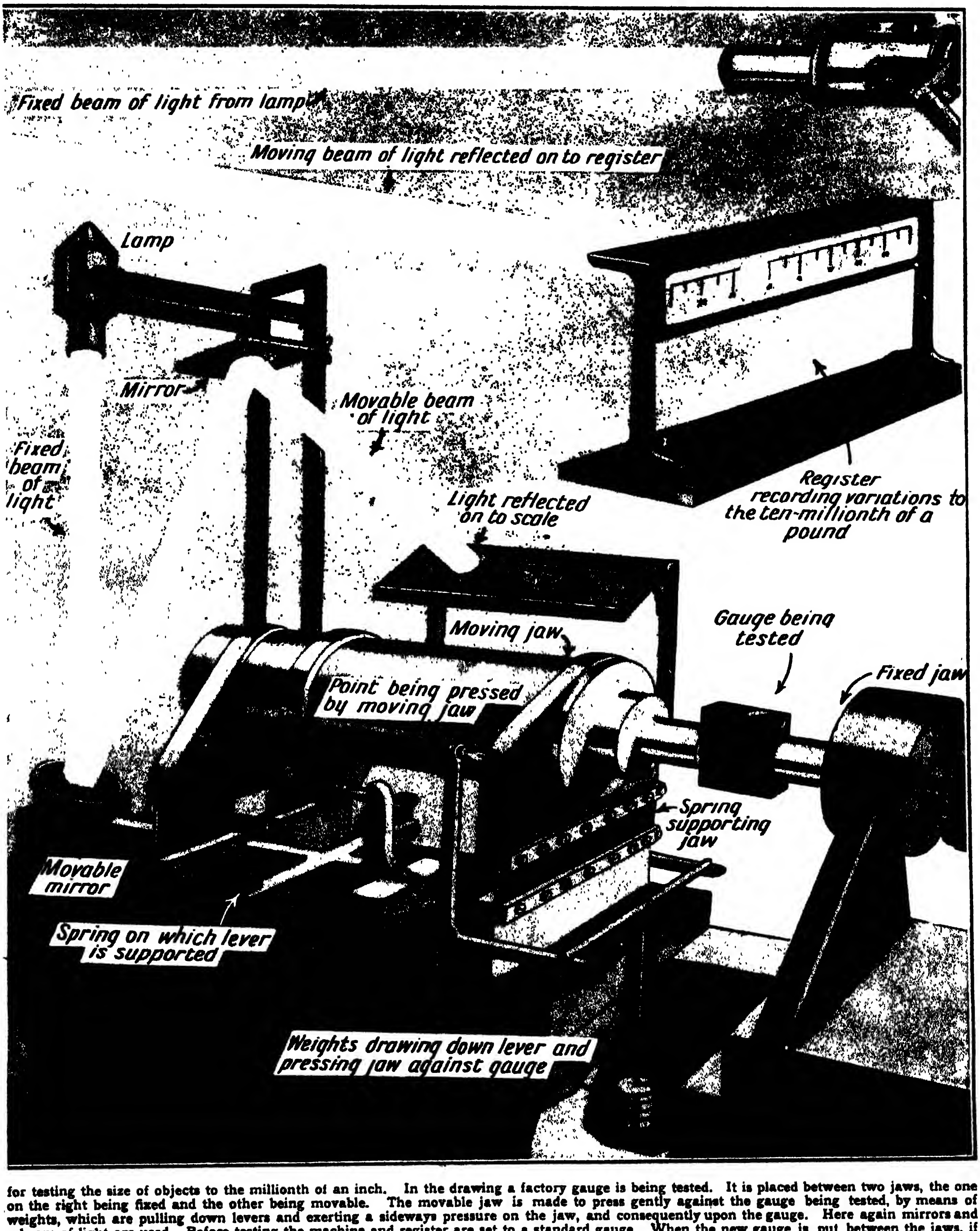
A little lesson in heat conduction

charred where it is against the wood, because wood is a bad conductor and does not carry off the heat; but against the metal—a good conductor—it will remain white, as we see illustrated in the last picture.

WEIGHING THE MILLIONTH OF AN OUNCE AND

At the National Physical Laboratory at Teddington all sorts of clever tests are carried out, and among others the testing of weights to almost the millionth of an ounce, and measures to the millionth of an inch, as shown here. On the left we see a weight being tested to the ten-millionth of a pound. The scales are perhaps the most delicate scales in the world. The vital points rest on knife edges, and the knife edges rest in agate. Fixed to the moving part of the balance is a mirror, into which is reflected from a square mirror above a fixed beam of light from a lamp at the other end of the room. Actually this lamp is about sixty feet away from the scales. The beam of light is reflected back upon the square mirror from the mirror on the balance, and from the square mirror it is reflected again on to a register placed under the lamp sixty feet away. The most minute movement of the balance causes the small round mirror to deviate, thereby displacing the beam of light, whose movement, owing to the distance it is reflected, is greatly magnified. In this way a variation of the ten-millionth of a pound can be detected. In this picture the standard weight on the left proves slightly heavier than the shopkeeper's weight being tested on the right. The light on the register has therefore moved an appreciable amount. The whole of the balance is carefully encased, so that changes of temperature and variations in atmospheric pressure shall not affect it. By means of a spirit level the balance is kept absolutely horizontal. The other instrument in the picture, shown on the right, is known as the comparator. This is

MEASURING TO THE MILLIONTH OF AN INCH



for testing the size of objects to the millionth of an inch. In the drawing a factory gauge is being tested. It is placed between two jaws, the one on the right being fixed and the other being movable. The movable jaw is made to press gently against the gauge being tested, by means of weights, which are pulling down levers and exerting a sideways pressure on the jaw, and consequently upon the gauge. Here again mirrors and a beam of light are used. Before testing the machine and register are set to a standard gauge. When the new gauge is put between the jaws, if it varies to anything up to the millionth of an inch from the standard gauge, this will be noticed by the changed position of the beam of light on the scale. Any minute difference between the new gauge and the standard gauge will cause the movable jaw to tilt a lever, which is suspended on springs, and this will tilt the movable mirror. However slight this tilt may be, the movement is tremendously magnified by the beam of light being reflected back upon the scale. If a gauge is put into this machine and the human finger is placed upon it for only a moment, the circle of light is clearly seen to travel along the register, showing that the metal gauge has grown infinitesimally larger by the heat from the finger. None of the standard gauges or those being tested is ever picked up by the hand. They are always lifted by means of small pincers, so that the heat of the fingers may not affect their delicacy. Such intricate measurements would have been thought quite impossible a century ago

MARVELS of ENGINEERING

ALL SORTS & CONDITIONS OF DREDGERS

Enormous improvements have been made in machinery used for excavating, whether on dry land or from the bottom of waterways and harbours Such machinery is only possible with steel of the strongest kind, for the strain on the digging device is enormous It is the dredger that has made the rapid extension of harbour works and the continuous deepening of channels possible, and in these pages we read and see something about the wonder of modern dredgers of various types

DREDGING is a very important branch of engineering and the power and efficiency of the dredging machine is constantly being increased

There are two main reasons for dredging One is to increase the depth of water in harbours docks and rivers and the other is to obtain valuable material which lies at the bottom of a river or lake

The dredging of harbours and docks and also of rivers and canals to increase the depth of water for shipping, is a regular industry which in many parts has to be constantly and systematically carried out

Of the dredgers themselves several types are in general use Perhaps the most familiar is the bucket or ladder dredger in which a continuous chain of steel buckets runs round and round a framework known to engineers as a ladder This extends from the floating craft to the bottom of the river or other watercourse being dredged

Up and Down

As the chain of buckets goes round and round it digs out the soft material at the bottom brings it up and then as the buckets turn over at the top the matter is discharged, either into the dredger itself or into a barge at its side

The dredger has a number of hoppers or compartments to receive the material and these have trap-doors at the bottom, so that if the dredged material is to be dumped at sea the hoppers can be emptied easily by the opening of the trap doors

Some of the big ladder dredgers have buckets that scoop up as much as 54 cubic feet of material each that is each bucket brings up more than two and a half tons at a time

Sometimes a bucket will strike a great boulder of rock and then the strain on the bucket and on the chain is enormous and provision is made by which if the obstacle is immovable a clutch slips, and relieves the strain These buckets often bring up stones weighing two tons or more

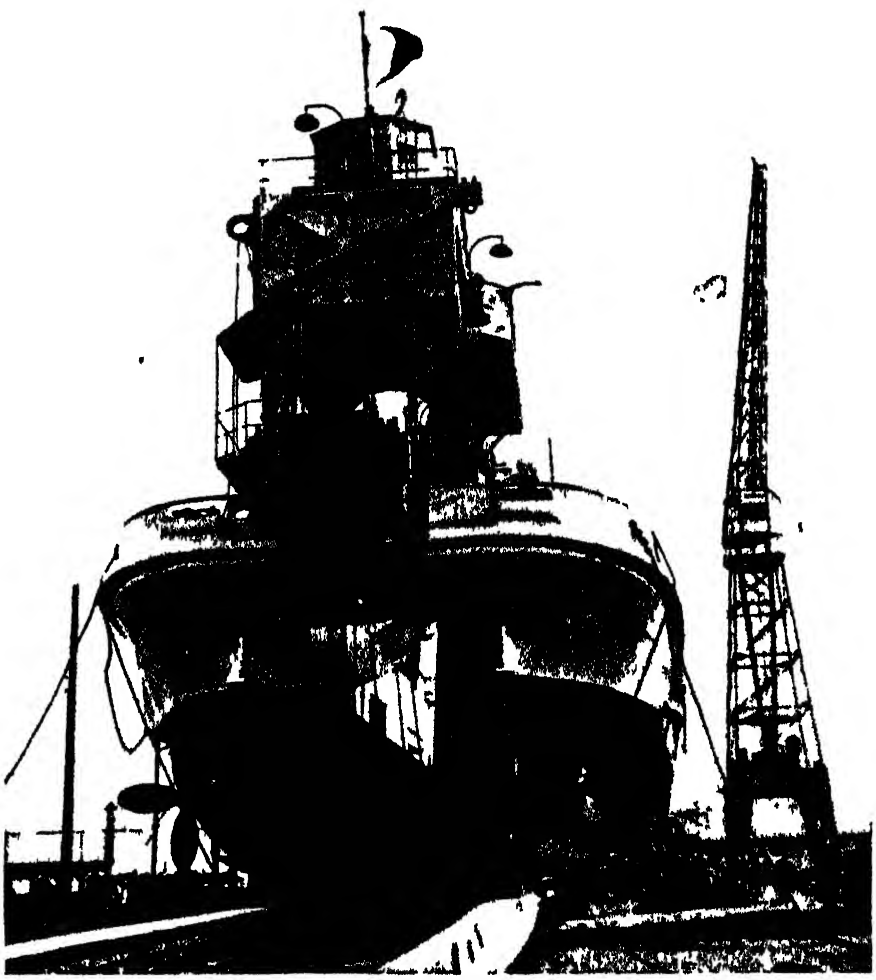
Another type of dredger is the suction dredger which as its name implies sucks up the material through an air tight pipe Such a dredger can deal only with fine mud sand or other material and it is largely used in gold dredging

The pump is of the centrifugal type In this there is a circular runner which revolves at tremendous speed in a round casing with a feed pipe and a discharge pipe As the runner revolves any material in the casing is flung outward through the discharge pipe by centrifugal force while fresh water and material rush up the feed pipe to take its place Thus a continuous stream of the dredged material is passing from the bottom of the river or canal and being poured out through the discharge pipe

In the Mersey

This type of dredger is used in such places as the Mersey, for keeping the channel open for ships One such dredger dredges and dumps twenty million tons of material a year

In addition to these two types there are also the grab dredger, in which a bucket in two hinged halves is let down and grabs the material, closing and bringing it up, and there is the dipper dredger, in which a bucket on an arm is let down and scoops up the material



The Pas-de-Calais, the biggest ladder dredger in the world, being launched at Dunkirk It can dredge up a thousand tons of gravel per hour We can see in the photograph how the middle of the dredger vessel is cut away in order to allow the ladder to be lowered, so that the chain of buckets can go round and round and bring up the material from the river or harbour bed **The way in which the ladder is lowered is shown on Page 569**

MARVELS of MACHINERY

THE IMPORTANCE OF THE SAW TO MAN

We are all coming to realise how much modern civilisation is based on machinery. Remove only one particular kind of machine from the Earth, and modern life could not go on as before. A great deal of our civilisation, for instance, would come to a dead stop if suddenly all forms of saws were to be instantaneously abolished, and here we read something of the saw's history and importance

THE saw is one of the most ancient tools known to man, for we find flint saws of the Stone Age, and the Ancient Egyptians used hand saws in form remarkably like those which we use now, except that like most oriental saws to-day, they had the teeth inclined towards the handle and so cut on the pull instead of on the push. The Egyptians even had saws which fitted into frames, like our buck-saws and hack-saws, and some of these could be worked by two people.

Think for a moment what life would be without the saw. We could chop down small trees, but how should we fell huge trees of great diameter? And having felled the trees, how should we saw them up into beams and planks? And even if we had the beams and planks, how should we make such things as boxes and chairs and tables and bedsteads and pencils and doors and drawers and bookcases and so on? We should indeed be helpless without the saw.

The man who first realised the value of a cutting instrument with teeth had hit on a tremendous discovery. Probably he found that the ordinary rough edge of a flint knife could do certain things that a smooth edge could not, and this gave him the idea of making teeth deliberately along the cutting edge. We do not know who he was, but he, like many other unknown inventors, should have a monument.

The invention of steel gave a powerful impetus to the development of the saw, and it will probably surprise many people to know that in the Middle Ages there were large saws worked by horse-power and water-power. These large saws worked up and down in a frame and were used for cutting up tree trunks and great beams.

But the greatest invention in connection with the saw, after the tool itself had been invented, was the production of the circular saw. An Englishman, Samuel Miller, took out a patent for a circular saw in 1770, and by 1790 circular saws were used a good deal. It has been claimed that similar saws were in use in Holland nearly a century earlier, but there seems no definite proof of this.

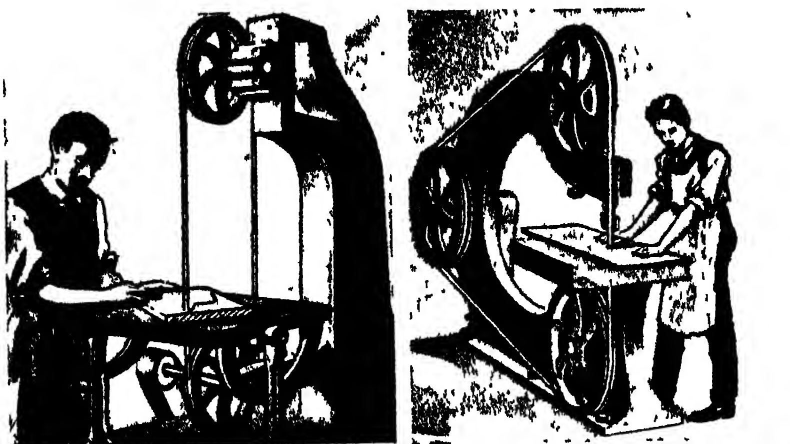
At first the circular saws were worked by hand, then by water, and after the invention of the steam engine, by steam. In some cases they were driven by horse-power, and there is a record of a 48-inch circular saw in the Western States of America which was driven by four horses walking round and round.

Of course those early circular saws were very crude compared with the wonderful implements that are produced to-day.

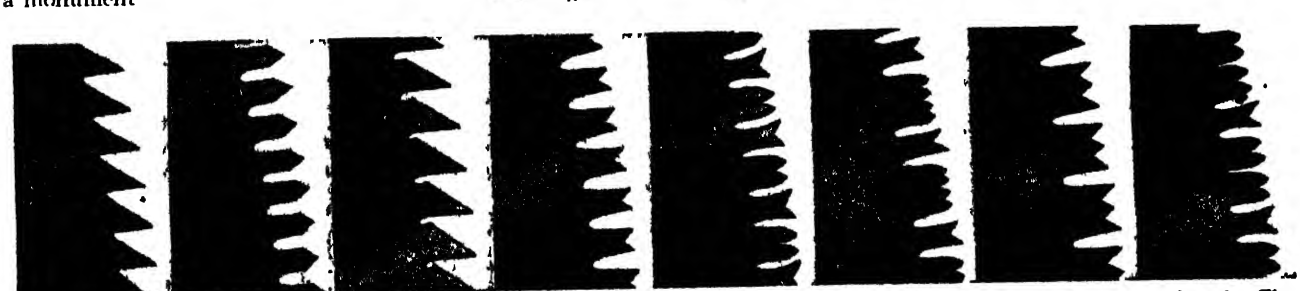
Another great advance in the development of the saw was when a way was found of inserting separate teeth in the disc, so that if any teeth were broken they could be replaced without scrapping the whole saw.

Anyone who has ever seen a circular saw at work in a big sawmill will have realised the enormous saving in labour of this ingenious device. One circular saw, attended by one man, will do as much work in a day as scores of men working with hand saws.

Still another remarkable development in the history of the saw was the invention of the modern endless band saw. The first one was patented by an Englishman, William Newberry of London, in 1808, but archaeologists say that the band saw was known to the Ancients. The band saw enables irregular shapes to be cut out with great speed, and like the circular saw, can also be adapted for the cutting of metals. It is made in many sizes, ranging from an eighth of an inch to 18 inches in width.

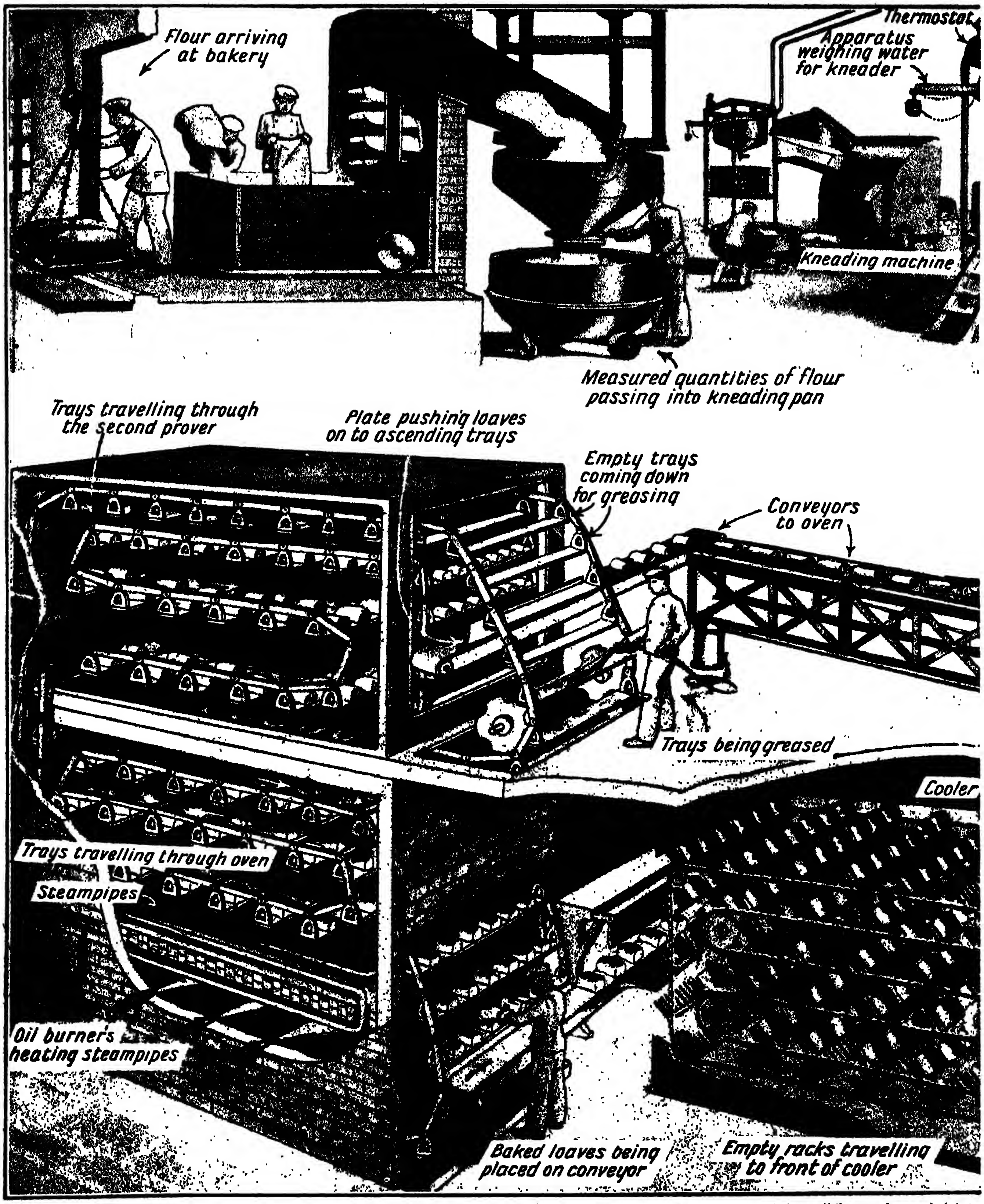


The endless band saw has one advantage over the circular saw in that it works not only very rapidly and continuously, but enables irregular shapes to be cut out. On the left we see a band saw used for wood, with a tilting table for bevel work, and on the right a band saw for sawing metals, with a third wheel and a frame set back to give room for large plates



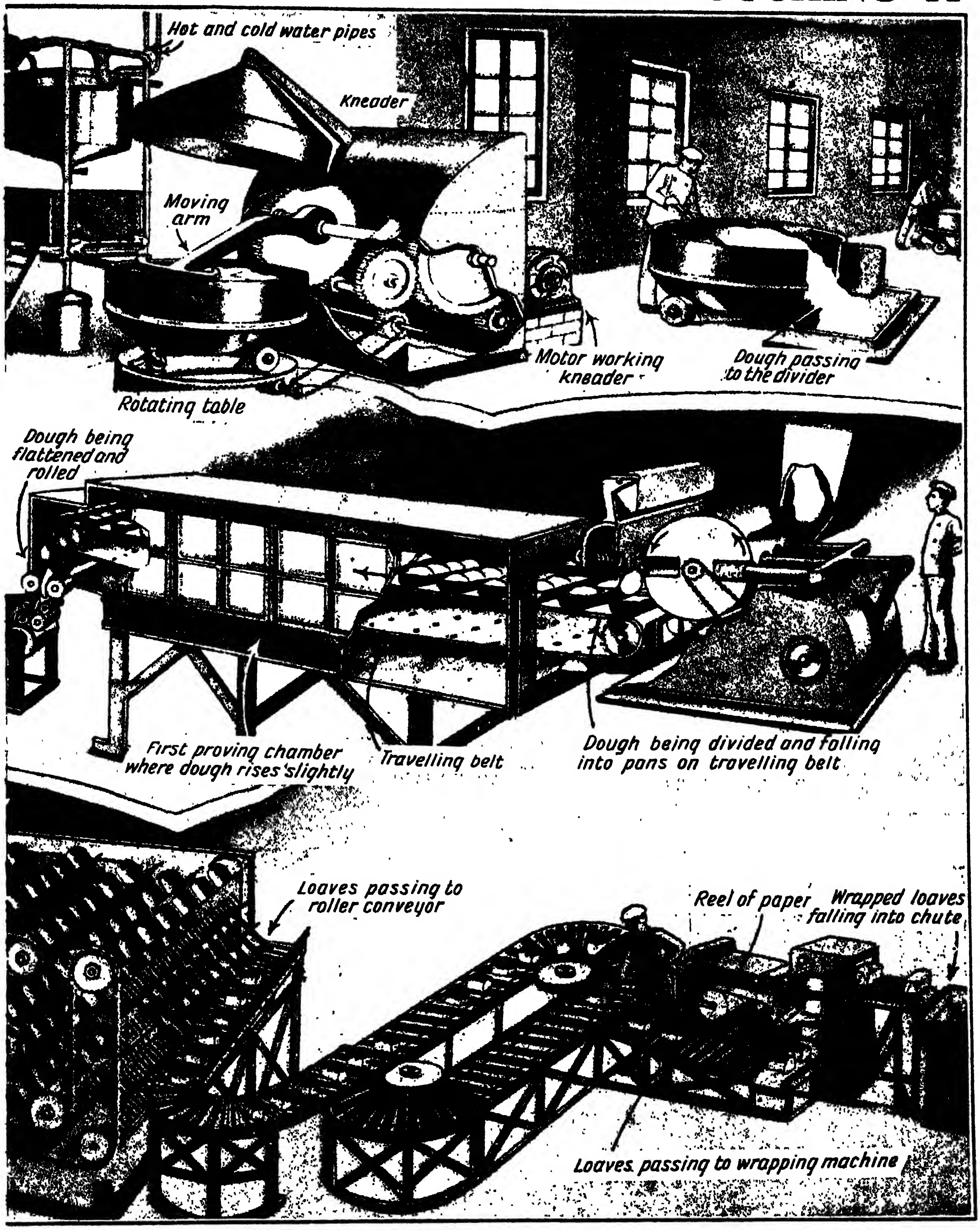
The making of saws is now a great science, and there is a vast variety in the form of the teeth adapted to various types of work. This picture shows only a few of the many forms of teeth now used in saws. Those to the right with the more elaborate teeth are crosscut saws

HOW OUR BREAD IS MADE BY MACHINERY



In this double-page picture we see the wonders of a modern bakery. When the flour arrives it is hauled to the top of the building and emptied into a large bin from which an elevator carries it up to a chute. It falls into a vessel which measures certain quantities by weight and drops these into kneading pans. The kneading pan is wheeled to a machine called a kneader, where a quantity of water, measured automatically, is added, and a moving arm worked by a motor kneads the flour and water into dough. The table on which the kneading pan stands is rotating all the time. As soon as it is ready the dough is wheeled away and shot through an opening to an apparatus called a divider on the floor below. Here the dough is divided into quantities each equal to one loaf, and these pass on a travelling belt through a warm proving chamber, where the dough rises slightly. At the

WITHOUT THE HUMAN HAND TOUCHING IT



end of the chamber it is flattened and rolled, and passes by conveyors to the second prover. Here the batches of dough are pushed automatically on to trays that are constantly ascending, these trays having been greased by a man with a grease spray. The loaves pass to and fro through the prover, and then descend into a hot oven, heated by steam pipes, where they again pass to and fro and come out baked. A man with gloved hands lifts them on to a travelling belt, which takes them to a cooling chamber, where they pass to and fro till they come out ready for packing. At the end of the cooler they are shot automatically on to a roller conveyor, where a man with gloved hands guides them to an automatic wrapping machine. Messrs. J. Lyons & Co., Ltd., allowed the artist, Mr. Goodwin, to make sketches for this drawing in their model factory

WHAT THE INSIDE OF A WATER-MILL IS LIKE

THERE are still a number of water-mills at work grinding corn in different parts of Great Britain, although the advent of steel and modern machinery is fast putting them out of action. They are unable to compete with the vast mills that now exist, full of intricate machinery costing many thousands of pounds, for the grinding of corn.

It is interesting, however, to see how the old water-mill does its work, and the picture given on this page shows in simplified form the various operations.

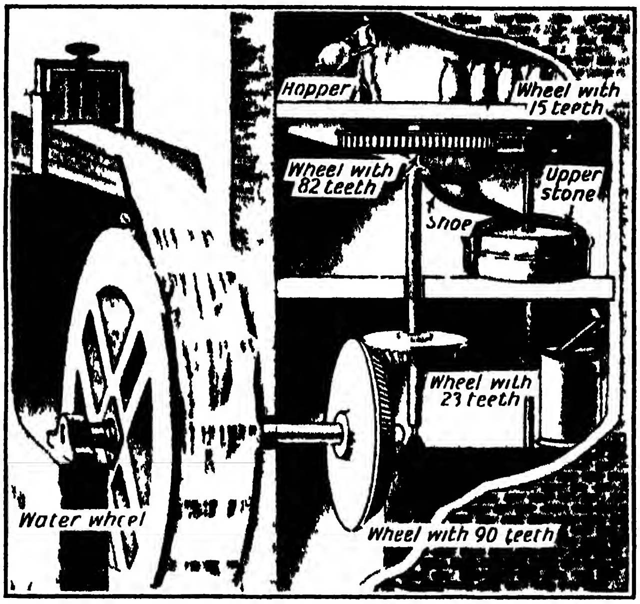
The power of running water is, of course, very great, its force depending upon the speed of the current. Formerly, even in England, it was a great source of power, and now, with the modern water-turbine utilising the energy at such places as Niagara Falls, a vast amount of power is obtained from water for the generation of electricity.

If into some small running stream we thrust a garden spade so that the water meets the broad surface of the implement, we shall find that it requires a good deal of exertion to resist the force of the current, which would carry the spade from before it. We can understand, therefore, that with a water-wheel fitted with a number of float-boards round its rim the power of running or falling water is sufficient to turn the wheel round and round.

We see on page 177 of this book the various forms of water-wheel used for mills. They go by the names of overshot, undershot and breast wheels. The picture on this page shows a mill with an overshot wheel.

As the wheel turns, its shaft or axle, which passes through the outer wall of the mill, turns a wheel inside the mill containing 90 teeth or cogs placed at an angle. This bevelled cogwheel drives a smaller wheel or pinion having 23 teeth, and this is fastened on an upright axis.

At the top of the upright shaft or axis is a wheel containing 82 teeth, and it connects with a pinion wheel working horizontally and having 15 teeth. That pinion is on a shaft or axle which supports and carries round the upper millstone. The lower millstone is stationary, and both stones are enclosed in a case or box with about two inches' space between the stones and the box all round.



In this picture we see how a water-wheel by means of geared wheels and shafts turns the upper millstone and grinds the corn

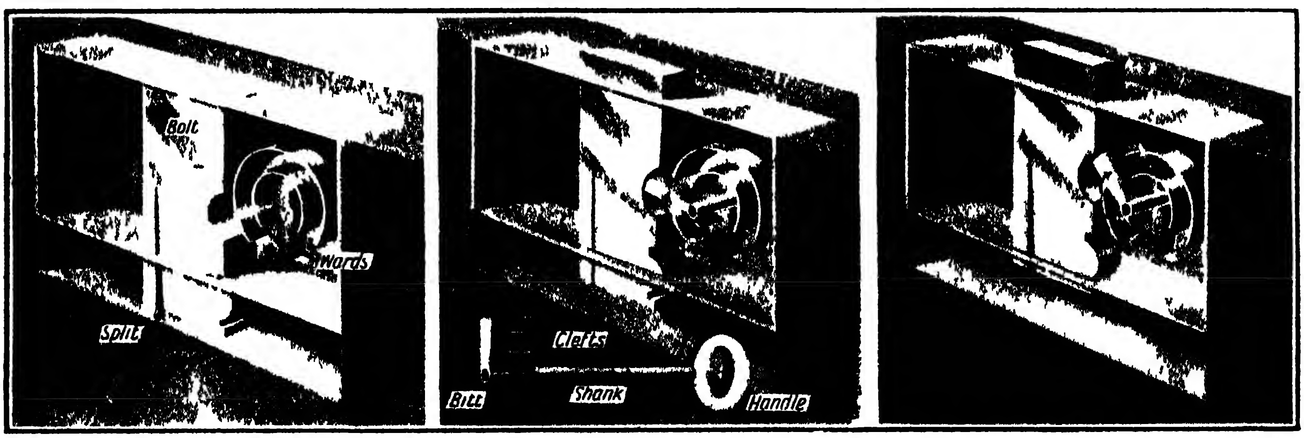
The corn is fed through a hopper in an upper floor and passes through a trough or shoe to the millstones. The shoe is continually shaken by the quickly revolving spindle, and so a constant supply of grain is delivered as the mill goes on working.

As the corn is ground it passes out all round the millstones and falls through a chute into a vessel below. But it is not yet fit for use, for the husks of the grain are mixed with the flour and must be separated. The ground corn is therefore taken to another part of the mill, where it is placed in hollow cylinders of wire, canvas or muslin, which are kept rotating by machinery not shown in this picture, and the coarser parts of the meal are separated from the fine flour.

A mill of this type usually has a pulley wheel at the top over which a rope can be passed for the hauling up of the sacks of corn that are to be ground, for, as can be seen, it is essential that the work should start at the top of the mill.

Water-mills of this kind were at one time dotted all over England. Wherever there was a stream or river there was a water-mill, but nowadays most of the water-mills have disappeared.

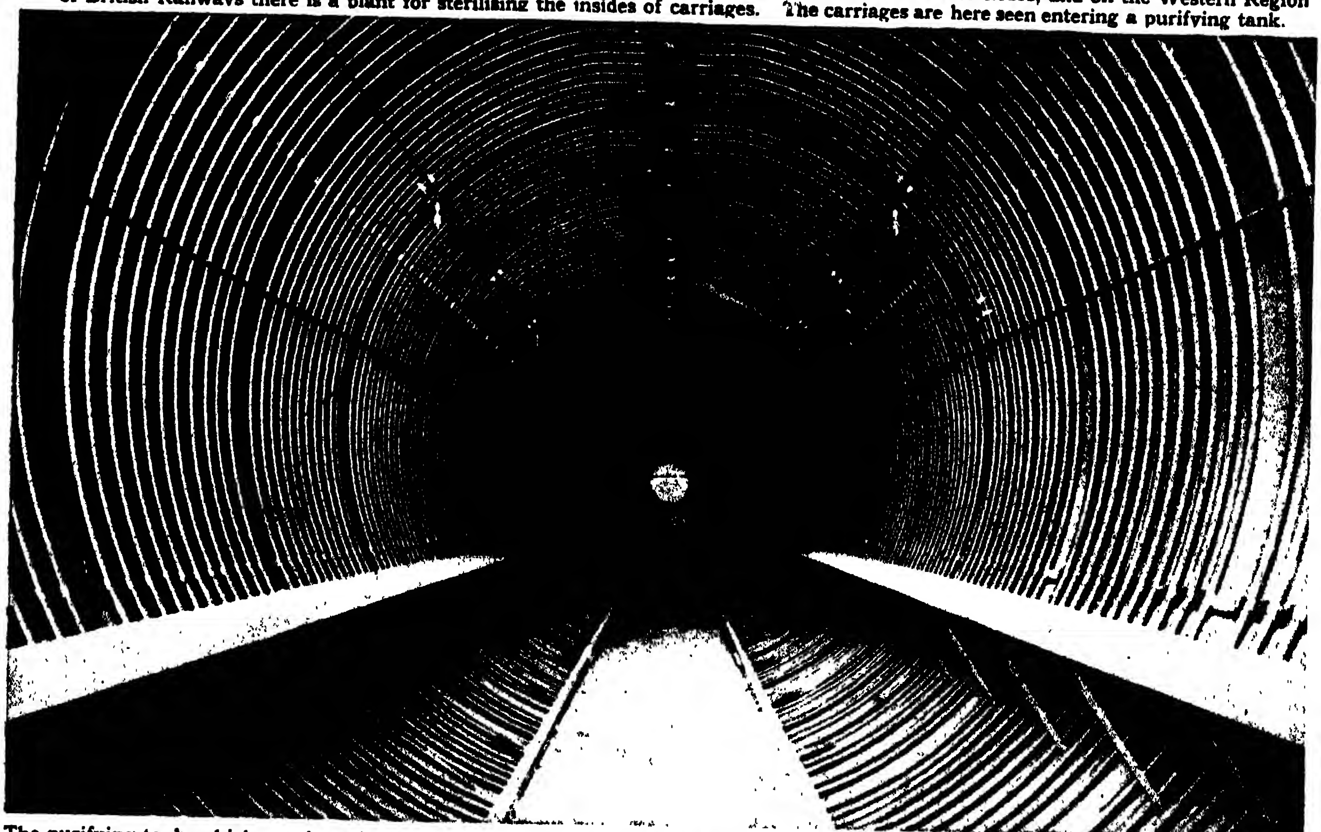
HOW A SIMPLE TUMBLER LOCK WORKS



There are many kinds of locks, and some of these have already been pictured and explained in this book, on pages 81 and 288. Here we see the simple form of lock which is used for drawers in desks and wardrobes. In the left-hand picture we see the drawer unlocked. The bolt has a split in it so as to give it a spring effect and keep it firmly in position. Fastened to the framework of the lock are several semicircular pieces of iron called wards. The key has slits known as clefts, and when the key is inserted in the lock and turned the wards fit the clefts. As the key is turned the bitt of the key goes into a notch in the bolt and raises the bolt, as seen in the second picture. Then when the turn of the key is complete the split in the bolt causes it to extend at the bottom so that a stump or projecting piece is forced outwards and catches on the edge of a slit in the frame and is held in position, locking the drawer, as in the third picture. Locks of this kind are called tumbler locks and are of a simple and inexpensive character.

CLEANING RAILWAY CARRIAGES BY MACHINERY

The carriages on many railways are nowadays run through a kind of tunnel in which sprays of water play upon the outside, doing the washing in a tenth of the time and much more thoroughly than was accomplished by the old hand method. The insides of the carriages also are cleaned by machinery. Powerful vacuum cleaners remove the dust from the cushions and floors, and on the Western Region of British Railways there is a plant for sterilising the insides of carriages. The carriages are here seen entering a purifying tank.



The purifying tank, which consists of a steel cylinder 85 feet long and over 16 feet in diameter, has a series of steam pipes throughout its length. The carriage goes inside, the cylinder is sealed up by an air-tight door and the steam pipes raise the temperature to 120 degrees Fahrenheit, sufficient to destroy any vermin and germs that may exist. The air is then withdrawn from the cylinder, leaving almost a vacuum. In this way the impurities are removed from the purifying tank and cannot get back into the carriages

HEALTH-GIVING VITAMINS IN COMMON FOODS

Fresh vegetables and fruits contain the vitamins without which it is impossible for us to be healthy. These wonderful substances, which have been discovered only in recent years, are within reach of the poorest. A costermonger's stall is a storehouse of vitamins

The vitamin called D is found in cod liver oil, liver, the yolk of egg, butter, milk and cheese, but it can also be produced artificially in certain foods by subjecting them to ultra-violet rays, and here we see dough being given a sun bath during the mixing process

THE GREAT IMPORTANCE OF VITAMINS

Everyone has heard about vitamins, those mysterious substances in our food which are essential to health, and yet cannot be seen, smelt or tasted. They were unknown at the beginning of the 20th century, but now their great importance is realised and we should certainly know something about them and the particular foods which contain them. Here is a great deal of information about the vitamins.

THE matter of diets and foods had long been studied by men of science, and it was known that human beings and all the higher animals needed several different kinds of food. These included those containing proteins for building up and repairing the tissues of the body, those containing mineral matter for building up the bones, those containing carbohydrates for yielding energy for heat and work, and fats for stimulating growth.

But, although all this was known, there was still some mystery about deciding upon a thoroughly suitable diet which should produce a healthy growth. Even when plenty of proteins, carbohydrates, salts containing mineral matter, and fats were taken, the result was not always a perfectly healthy growth.

One thing had been found by experiment: a certain quantity of vegetables and fruit in the diet was necessary for health, and the Admiralties of various countries used to order large quantities of dried vegetables for use on their ships going for long sea voyages, when no fresh vegetables would be available. But somehow these dried vegetables, although they tasted almost the same as fresh vegetables when prepared properly, did not produce the same result.

That great navigator Captain Cook knew that he could keep his men healthy and free from scurvy if he gave them plenty of fresh greenstuff, and so wherever possible he called at the different countries he sighted to collect fruits to add to the ship's diet.

Early in the present century it was found that in certain natural foods very minute quantities of substances existed whose composition was unknown. The substances could not be extracted as fat can be extracted from milk, or sugar from beetroot; but, nevertheless, exhaustive experiments showed that the absence of these substances from the diet led to sickness and disease.

Further experiments and investigations led to the discovery of more of these mysterious substances, and the name of vitamins was given to them, a word made up from the Latin word "vita," meaning "life," because the substances were absolutely essential to life and health.

Vitamins originate in plant life and are present in the flesh tissues of animals that live on plants; hence vitamins occur in varying proportions in both animal and vegetable foods. Vitamins are classified by letters of the alphabet and by subdivisions of certain letters.

Vitamin A. This is found in animal fats, such as butter, cream, egg yolk, and cod-liver oil. Margarine, unless artificially fortified with it, does not supply vitamin A, nor does lard or bacon fat, unless the pig is fed on green foods. Food short of vitamin A causes children to lose weight and become likely to catch various infectious diseases.

Vitamin B and B_1 include a number of somewhat similar vitamins which, however, act on the body in different ways. Shortage of vitamin B in the diet is the cause of berri-berri (a common disease in Oriental countries).

Vitamin B_2 is a group term which includes vitamins containing one or other, and sometimes all, the three substances nicotinic acid, riboflavin and adermin. Deficiency of nicotinic acid affects the nervous system, the skin, stomach and intestines, and is one of the causes of pellagra (a form of skin disease). Lack of riboflavin causes eye inflammations, pimples, and skin troubles such as cracked lips. Shortage of adermin in the food may induce skin and scalp diseases such as pimples and seborrhoea (falling out of the hair).

Vitamin C is necessary to enable the body to resist scurvy and anaemia (weak blood); deficiency in vitamin C greatly lowers resistance to infection.

Vitamin D. Deficiency of this vitamin is a cause of rickets and chilblains.

Vitamin E. A diet rich in this vitamin gives relief to some nerve and muscular troubles.

Vitamin K is essential to the clotting of the blood, and it benefits sufferers from nettle-rash and chilblains.

Vitamin P is generally associated with vitamin C and has similar effects.

VITAMIN VALUES OF COMMON FOODS

VITAMIN A

Cod-liver oil	****
Liver (fish and animal)	***
Fish roe	**
Egg yolk	**
Butter	**
Green vegetables	**
Carrots and tomatoes	**
Dried apricots	**
Meat (animal and fish)	*
Milk (pasteurised)	*
Cheese	*
Fresh fruit	*
Whole cereals	*

VITAMIN B, B_1

Yeast and yeast extracts	****
Middlings, bran, peanuts	***
Dried peas	**
Lentils	**
Wholemeal wheat	**
Rye	**
Oatmeal	**
Rice	*
Pork, ham, bacon	**
Liver, kidney, heart	**
Egg yolk	**
Hard roe	**
Fruit	*
Vegetables	*
Lean meat	*
Soft roes	*

VITAMIN B_2

	Nicotinic acid	Riboflavin	Adermin
Yeast (dried)	****	***	***
Yeast extract	***	***	***
Liver	***	***	***
Kidney and heart	**	**	—
Meat, lean	**	*	*
Fish	**	—	*
Wheat meal	**	*	*
Egg	*	*	-
Maize	*	*	*
Rice	*	*	*
Oatmeal	*	*	—
Potato	*	—	-
Spinach	*	—	-
Other vegetables	*	*	*

This table shows the vitamins present in various foods. The comparative content of any one vitamin for specific foods is indicated by one or more stars, one star representing unity. Thus in the vitamin A foods, cod-liver oil contains twice the vitamin A value of green vegetables, and four times the vitamin A value of animal and fish meat.

VITAMIN C

Rose hips	******
Black currant	*****
Brussel sprouts	*****
Parsley	*****
Orange juice	****
Strawberry	****
Asparagus	****
Spinach	****
Cauliflower	****
Cabbage	****
Watercress	****
Liver	***
New potatoes	***
Lemon juice	***
Red currant	***
Rhubarb	***
Grapefruit	***
Gooseberry	***
Loganberry	***
Swede	**
Bean	**
Lettuce	**
Raspberry	**
Tomato	**
Milk	*
Beet	*
Parsnip	*
Carrot	*
Onion	*
Apple	*
Banana	*
Plum	*
Dandelion	*

VITAMIN D

Cod and fish liver oils	****
Liver (fish and animal)	***
Fish meat	**
Fish roes	**
Egg yolk	**
Milk (pasteurised)	*
Butter	*
Cheese	*

VITAMIN E

Wheat	***
Cereals	**
Green leaves	**
Vegetables	**

VITAMIN K

Liver	***
Green leaves	***
Animal fats	*

VITAMIN P

Oranges	***
Lemons	**
Prunes	**
Grapes	**
Grapefruit	*
Rose hips	*

But he did not know that it was really Vitamin C that cured or kept away the scurvy from which mariners used to suffer so terribly This vitamin is particularly abundant in plants of the cabbage family, and in the juices of citrous fruits like lemons oranges and grapefruit It is also found in the tomato That is why we should always eat plenty of those fruits

Certain diseases common in the East and elsewhere can be cured by giving other vitamins For instance beri beri a disease like dropsy, can be cured by Vitamin B1, and another painful disease, pellagra, which often leads to insanity, can be cured by Vitamin B2

Vitamin E, which is found in the germ or essential part of wheat and in lettuce leaves is also very important and valuable for when it is given in their diet to animals they produce young much more freely and rapidly

A remarkable thing about Vitamin D is that it can be produced in certain foods by subjecting them to ultra-violet rays and as it is valuable in curing or preventing rickets experiments were made in subjecting little sufferers from this disease directly to ultra violet rays The result proved of enormous benefit

So one discovery follows rapidly on another The study of vitamins is still being carried out all over the world, and now, while we cannot exactly get a box or bottle of vitamins, in the same way as we can get a box of sugar or a tin of salt, we can get substances with the vitamins tremendously concentrated In many cases boiling or baking destroys the vitamins, so let us see to it that our diet always includes a large proportion of fresh foods—fruit, vegetables, salads, uncooked milk and eggs

We may be thankful that these valuable substances are contained far more in the cheaper foods like cabbages, tomatoes, herrings and cod, than in those far more expensive canned and bottled foods which we see in the shops Indeed, the costermonger's stall contains far more vitamins than the grocer's shop

The substances in which Vitamins B1, B2, C, D, E and F are found Vitamin B1 (also called F) preserves the health of the nerves, improves the appetite and aids growth in babies , B2 (also called G) prevents various skin diseases , C maintains a healthy condition of the blood capillaries and prevents scurvy , D aids bone growth and the clotting of the blood, and prevents rickets and tooth decay ; E aids the life and growth of babies before birth

LIFE ON THE EARTH SIX MILLION YEARS AGO

In this picture we are given some idea of what life was like on the Earth in the Jurassic period, which some geologists tell us began about six million years ago Reptiles dominated the world, and there were giant dinosaurs, including the famous diplodocus, a creature as long as a small street Some of these giant reptiles were vegetarian and others carnivorous Living forms were never so grotesque as during this age Several dinosaurs are shown, and on the left behind the tree is a stegosaurus Some of the crocodiles lived in the sea. There were great flying lizards or "dragons of the air," and by the end of the Jurassic Age the earliest bird was seen, known as archaeopteryx It was about the size of a crow, and had claws on its wings Vegetation consisted of coniferous trees, ferns and cycads

THE GIRAFFE'S LONG NECK & TONGUE

The giraffe is a strange-looking animal, and it is perhaps not surprising that a farmer, looking at one in the Zoo for the first time, exclaimed, "It can't be true!" Here we read something about its form and habits

No other living creature has such an amazingly long neck as the giraffe, or can reach up so high. But the giraffe is not a freak. In every way it is wonderfully adapted to the circumstances in which it has to live In the first place, it has many enemies, and its coloration is so arranged as to camouflage it almost completely in its native haunts.

Of course, in a zoo it is remarkably conspicuous, but travellers tell us that in Africa, where it lives, the dappled hide of the giraffe blends so harmoniously with the splashes of light and shade formed by the Sun glinting through the foliage of the trees, that even the sharp-eyed natives are unable to detect it even when quite close. There are several varieties of giraffe, but although their markings vary, they are all well protected by their coloration.

The senses of sight and hearing are very highly developed, and the giraffe's head, carried on its elevated neck, enables it to keep a sharp look-out for foes When danger threatens the giraffe runs off, travelling at over thirty miles an hour, and its gait is very curious, the legs being straddled at each step. The animal gives the impression of sailing rather than running. It takes a good horse to overtake a giraffe. At a hard gallop it can spin along for miles.

If a lion or other beast attacks it, the giraffe defends itself by kicking out with its legs, and it can deliver a blow of such terrific force as to stun, if not to kill, an animal.

The food of the giraffe consists of leaves plucked from the tops of the trees, and here the curious formation of the animal enables it to secure all it wants.

First of all the fore-quarters are greatly elevated, being raised well above the hind-quarters. Then there is the long neck, which nevertheless has only the same number of bones as the neck of a hippopotamus or elephant. The length is obtained not by increasing the number of bones, but by the lengthening of them individually.

Reaching the Tree-Tops

The head is so constructed that it can be raised perpendicularly, thereby forming a continuation of the neck. Finally, the hairy upper lip can be extended to a great distance, and beyond that the extraordinarily long tongue, sometimes more than eighteen inches, can be shot up and twisted round leaves and branches that would otherwise be out of reach.

The great length of the forelegs and neck have one disadvantage, and that is that the giraffe can only drink by getting itself into a rather awkward position. It has to straddle its front legs before it can bring its head to the ground. It is when the animal is drinking at night that its bitterest enemy, the lion, often springs upon it.

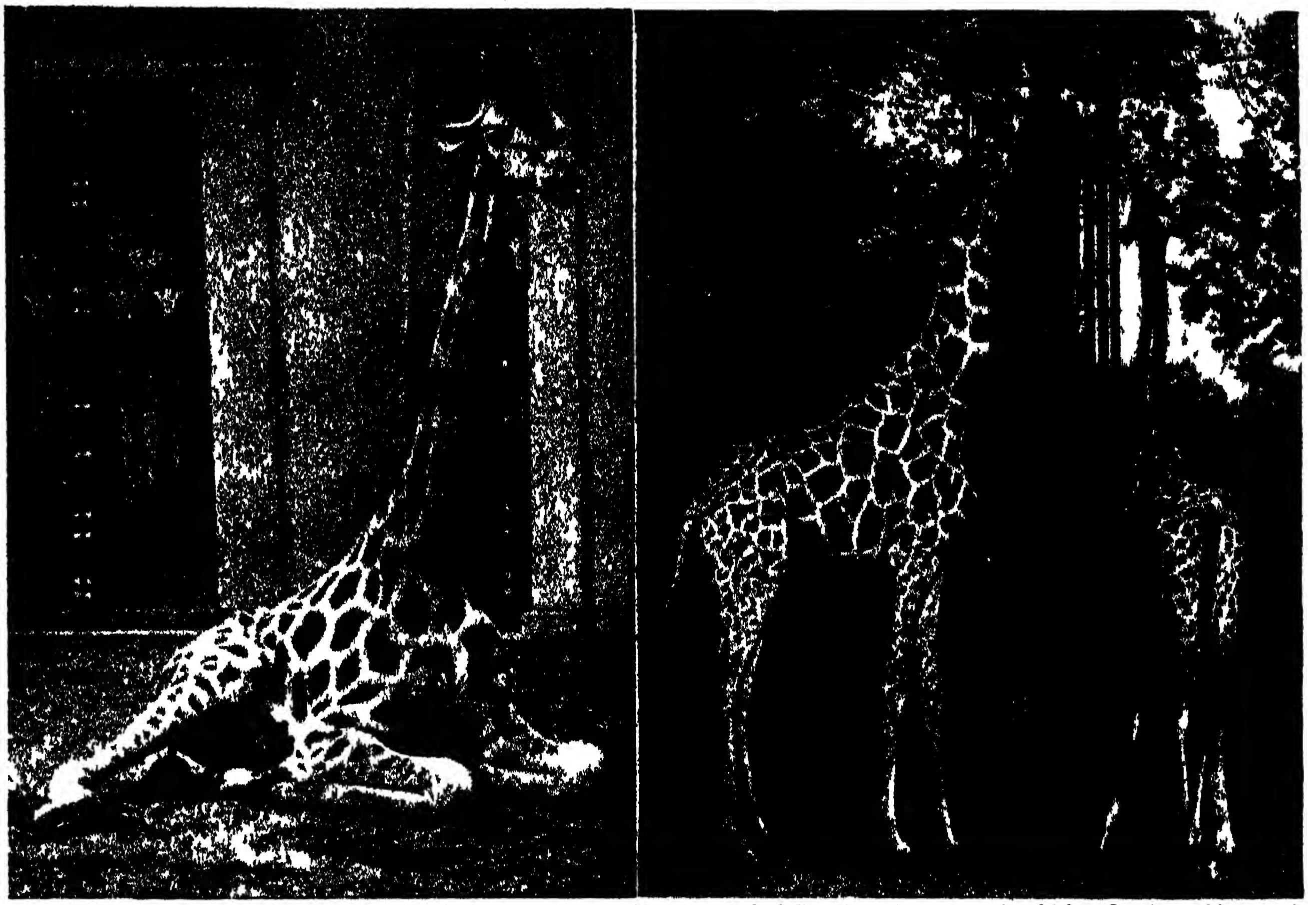
The giraffe has a pair of horns six inches or so high between the ears, and old male giraffes often have a third horn rising from the forehead. A variety of giraffe found in Uganda has two small additional horns behind the principal pair. The horns of the giraffe, however, are never used as weapons.

Although the giraffe was known to the Ancients, who called it the camelopard, regarding it as a cross between the camel and the leopard, it was not till 1827 that the first living giraffe arrived in England, being presented by the ruler of Egypt to King George IV. It died two years after its arrival, but nine years later four more giraffes arrived in London.

Giraffes go about in herds, although these are not so large nowadays as they were fifty or sixty years ago. Sir Samuel Baker, the famous traveller, once counted a herd of 154. He tells us that there is nothing to compare in beauty throughout the whole animal creation with the eye of a giraffe. It is large, dark and liquid, and has an expression of great gentleness. Yet giraffes sometimes get vicious, when they begin to kick with both fore and hind feet. The only relation of the giraffe is the okapi.

A giraffe at the London Zoo putting out its tongue, which is often more than eighteen inches long, and in the animal's wild state is used for reaching the topmost leaves and branches of trees. It can curl round the twigs and pull them down to the mouth

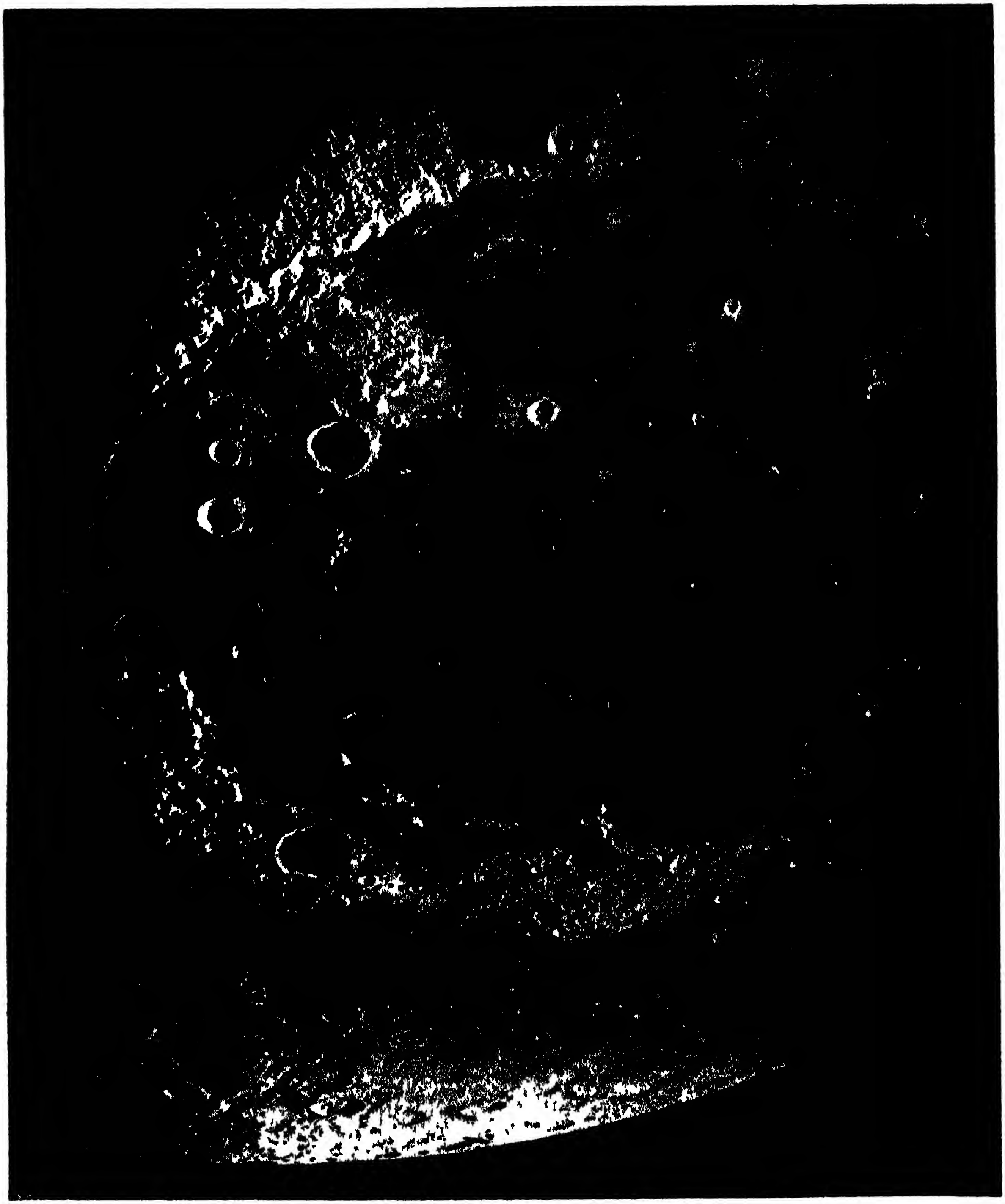
THE TALLEST OF ALL LIVING MAMMALS



The giraffe is the tallest of all living mammals, and its peculiar form is wonderfully adapted to its mode of life. In the wild state it lives upon the leaves and branches that grow on tall trees, and its long legs, extended neck and long tongue enable it to reach these with ease. On the left we see how the giraffe rests, and on the right how it extends its head to reach the upper leaves

A group of giraffes in their native haunts in South Africa. In the photograph the animals look conspicuous, but actually their coloration is so protective, and camouflages them so well, amid the play of sunshine and shadow, that even when a traveller is near it is difficult to distinguish them. Keen-eyed natives, trained to detect animals, are often quite unable to see them a few yards away. A full-grown giraffe is often 20 feet high and has to straddle its long forelegs very wide to reach the ground with its mouth

THE GREAT "SEA OF RAINS" ON THE MOON



The details of the Moon's surface can be plainly distinguished by means of the huge 100-inch telescope at Mount Wilson Observatory in America, as can be seen from this magnificent photograph reproduced here by courtesy of the Observatory. It shows the great level plain which was named by the old astronomers Mare Imbrium, or Sea of Rains, because they supposed that it must be an ocean on the Moon's surface. Possibly in past ages it was a sea, but now it is a great, flat desert about two million square miles in extent. In the top part of the photograph can be seen the range of mountains known as the Apennines with the great crater Archimedes just below it, and two other craters, Autolycus and Aristillus, to the left. At the bottom is seen the crater called Plato, and at the top, at the end of the Apennines, another crater, Eratosthenes. Just above the crater Plato can be seen an isolated mountain which is known as Pico

WONDERS OF THE SKY

NEW PLANET NAMED BY A LITTLE GIRL

Not very many years ago it was thought that the orbit of Neptune marked the limit of the solar system to which our Earth belongs. But in the last few years we have learnt that this is not the case. There is another planet beyond Neptune and it has been given the name of Pluto, a name which was suggested by a little English girl of eleven, Venetia Burney, of Oxford, a great-neice of Mr. H. G. Maden, the science master at Eton College, who proposed the names Phobos and Deimos for the two moons of Mars

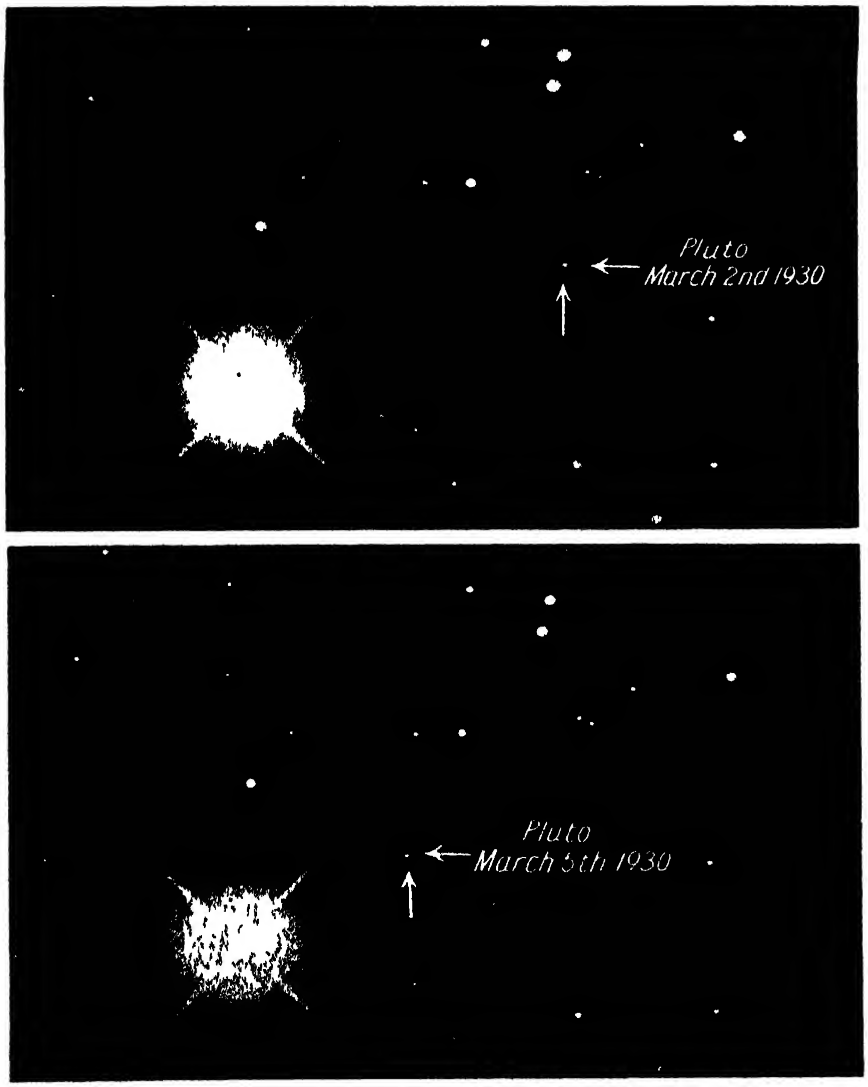
The most distant member of the solar system, the planet Pluto, was discovered by photography. It appeared on successive photographs, and as it had changed its place astronomers knew that it was not a star, but was a planet, or "wanderer" in the heavens.

It was discovered by the astronomers at the famous Lowell Observatory at Flagstaff in Arizona. It is the third large or major planet to be discovered in human history, for all the planets as far as Saturn have been known from prehistoric times. Uranus was discovered in 1781 and Neptune in 1846. Pluto was found in 1930.

The actual discovery of the planet on the photographic plates was made by a young astronomer, Mr. Clyde Tombaugh, but a quarter of a century or more ago Professor Percival Lowell calculated by mathematics that there must be another planet beyond Neptune, and this led to the search.

Not much is known about this distant planet, but it is believed to be smaller than the Earth, from which, when discovered, it was distant nearly 4,000 million miles. Its great distance, and its dim light, which takes about five-and-a-half hours to reach us, make it very difficult to take any measurement of its disc.

As we know the Sun is not quite in the centre of the Earth's orbit, for in winter we are about three million miles nearer the Sun than we are in the summer. But the eccentricity of Pluto's orbit is much greater than this. When Pluto is nearest the Sun he gets even closer than Neptune, but as the orbit of the new planet is inclined at a considerable angle to the general plane of the orbits of other planets, his path and that of Neptune do not cross each other.



The two photographs a comparison of which showed that a supposed star had changed its position, proving that it was a planet. The bright patch is the star Delta in Gemini

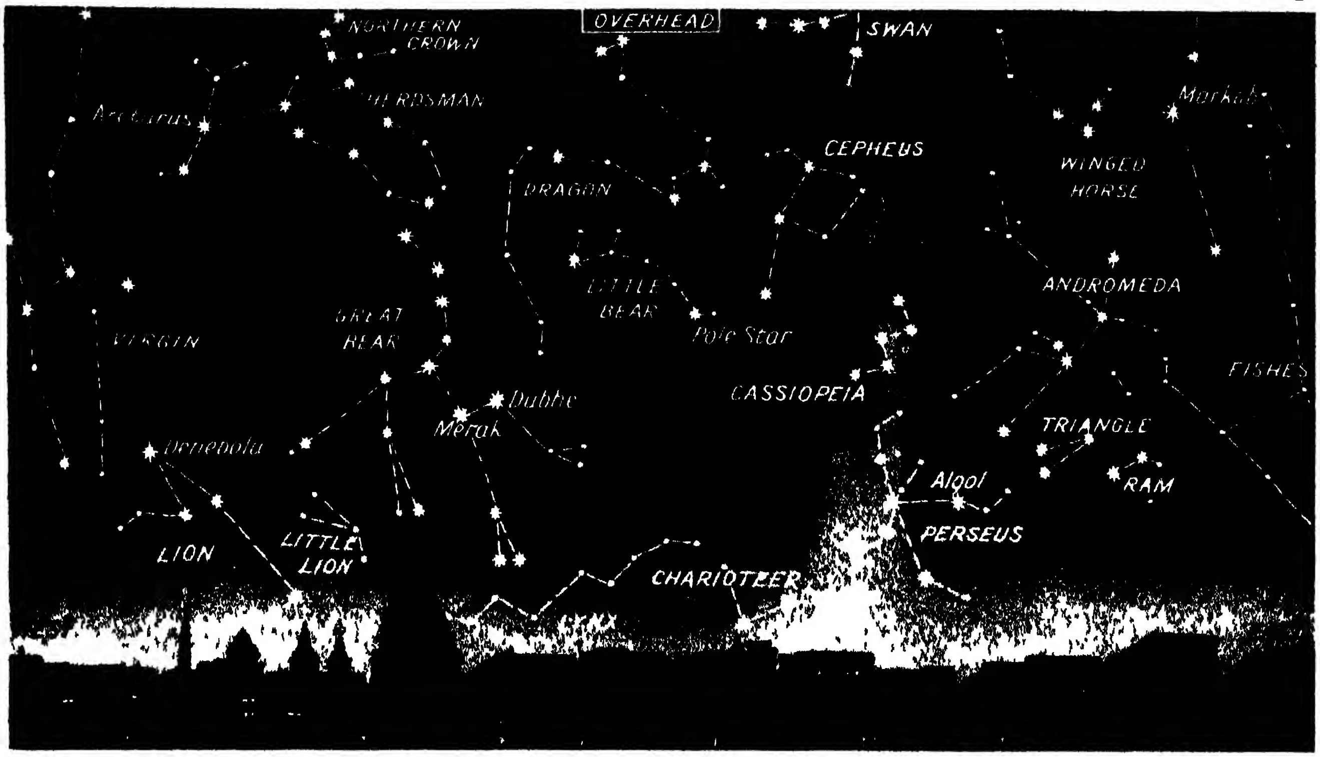
Pluto is believed to be very massive and heavy, as though it were a frozen and condensed world, which it probably is. To any inhabitant who might be on Pluto the Sun would appear no larger than a bright star.

The enormous advantages of photography to the astronomer are clearly seen in the case of Pluto, for the photographs of that part of the heavens where he appears taken in past years have been carefully examined and from them the scientists have been able to calculate roughly the orbit of this distant planet. They did not expect to be able to do so for some years and had it not been for the photographs they would have had to wait a long time.

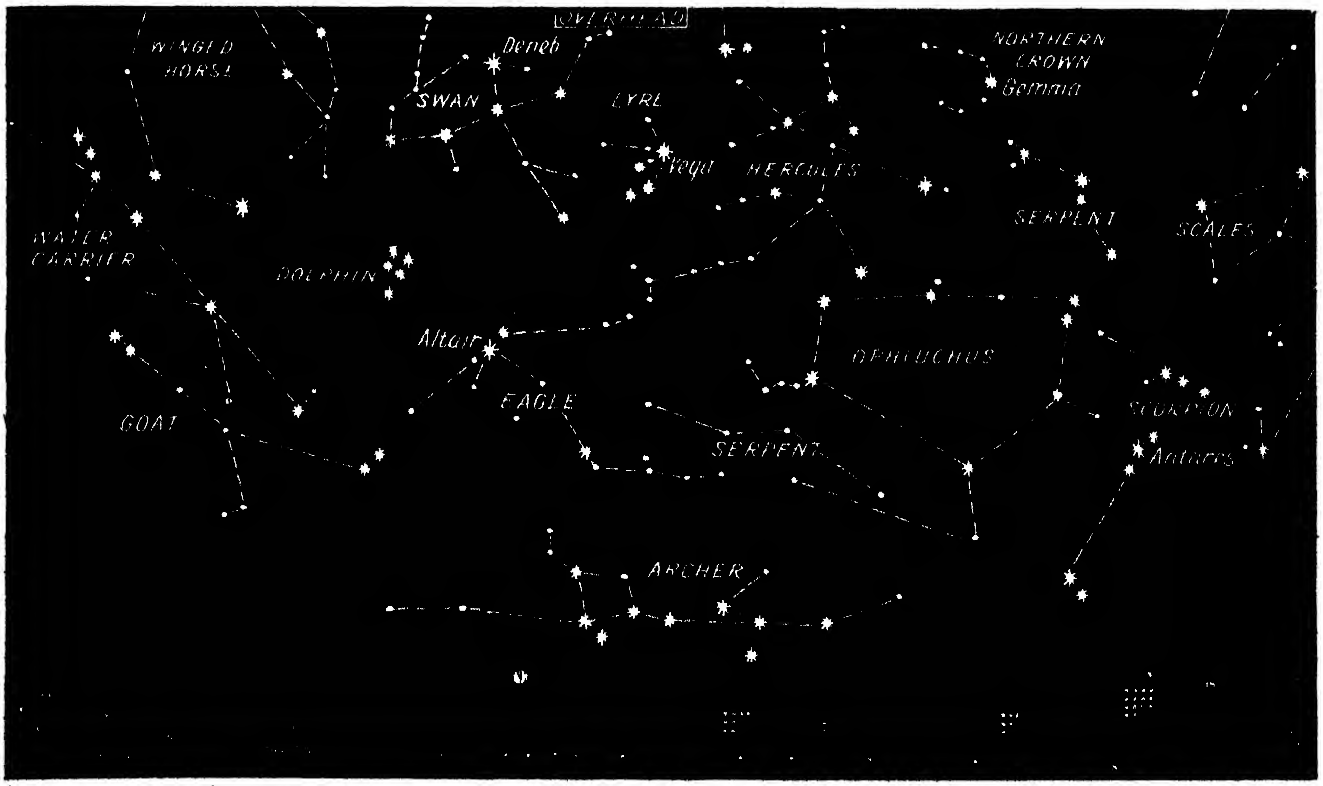
It is a very wonderful thought that the photographs which have been taken during past years of different parts of the heavens may at some future time reveal still another planet of which, so far, there is no hint or knowledge.

It must be remembered that the task of examining these star maps is a very tedious one. When one remembers that there are hundreds of millions of stars scattered over the heavens one can easily understand that to search among these for a possible planet, appearing as a mere point of light among all the rest, is a work requiring the most amazing patience and the greatest care and skill on the part of the astronomer.

HOW TO RECOGNISE THE CONSTELLATIONS



In this picture we see the principal constellations as they appear in the sky if we stand looking directly north at eleven o'clock in the middle of July The faint, cloudy band rising from the horizon is the Milky Way, which is really a vast universe of stars to which our solar system belongs. If we could see this great system from distant Space it would look very much like the great nebula in Andromeda. The most easily recognised of all the northern constellations is the Great Bear. We can always pick out that part of it which is called the Plough, and by means of the two pointer stars, Merak and Dubhe, find the Pole Star near the point round which the heavens rotate



Here we see the principal constellations in the heavens when we look directly south. It is interesting to compare these picture-diagrams of the constellations with those which appear on pages 130 and 415. It will be seen that the heavens appear to be circling round during the year, and some of the constellations which at one time of the year are clearly visible disappear below the horizon at another season, only to reappear some months later We can best see the change by following the apparent course of the Plough. Other constellations can be traced in relation to it. Here again, as in the picture of the northern constellations, we see the Milky Way as a faint cloud-like band

A FOOLISH KING LOSES HIS HEAD

Charles the First's was a tragic reign, for it led to the great Civil War, in which so many brave men on both sides lost their lives. It was also a very important reign, for in it were laid the real foundations of the English political liberty which we enjoy to-day. In these pages we read the story of how this king exasperated and defied his people and so came to lose his head

It is rather the fashion to speak of Charles the First as a bad king but a good man. That he was a bad king no one who pays any regard to the facts can dispute, for during the whole of his reign he was constantly breaking the law. He extracted money from his subjects quite illegally, and any who would not pay were put in prison contrary to the law and to the express pledges given by the King himself.

When in the end his subjects cut off his head they were only taking a leaf out of the King's book, and he could hardly complain that his subjects broke the law when he himself had been setting them the example of lawlessness for nearly a quarter of a century.

But if he was a bad king, can we say that he was a good man? After considering the whole of the facts of his life, the most we can say is that he was a good husband and a kind father. He was loyal and faithful to his wife, which few, if any, kings had been before him, and he was loving and gentle to his children.

But beyond this we can hardly describe Charles the First as a good man. He was faithless to friend and foe alike. No matter how loyally a man might serve him, facing opposition and danger in the King's interests, Charles, when his own safety or welfare was imperilled, left his friends to the tender mercies of his foes.

His signing of the death warrant of Lord Strafford, who served him through thick and thin, is one of the most disgraceful episodes in English history, and so faithless and untruthful was the King, who for long was quite wrongly described as a "Martyr," that in the end nobody could trust his word. The best we can say of Charles Stuart is that he died better than he lived.

As an infant he was so feeble that it seemed hardly likely that he would survive, or at any rate become a normal man. His ankles were too weak to allow him to stand or walk alone, and it was a very long time before he learned to speak. But his guardian, Lady Carey, looked after him so well that his health improved and he finally became a strong man, expert in all kinds of athletic exercises, such as vaulting, riding, and shooting with crossbow and musket, and was also something of a scholar and theologian. His father used to say that "he could manage a point of controversy with any prelate." He spoke and read French and Italian, was a master of the classics and mathematics, and also had a good knowledge of painting, architecture and music.

Unfortunately he was of a very obstinate disposition, and this led both him and his country into trouble. Even before he came to the throne he looked upon the House of Commons as an enemy that needed chastising. Writing in 1621 to his bosom friend, the Duke of Buckingham, to whom he gave the pet name of 'Steenie,' he said: "Steenie, the Lower House this day has been a little unruly, but I hope it will turn to the best, for before they rose they began to be ashamed of it; yet I could wish the King would send down a commission that if need were such seditious fellows

Charles the First demanding the arrest of the five impeached Members in the House of Commons. The Speaker is asserting the privileges of the House. From the painting by J. S. Copley

might be made an example of to others.'

At last James died and Charles mounted the throne and at once the trouble began. The English people, although they had always been great fighters for liberty, were confirmed monarchists. The thought of doing without a king had never occurred to anyone. Yet Charles by his persistent law-breaking and trampling on the liberties of his subjects turned a large proportion of them into Republicans. And when he lost his head it was only the natural climax to a long course of events for which he himself was responsible.

It has been said quite truly that Englishmen love liberty and respect the law. It was the lawlessness of Charles and not his constant demands for money that roused the ire of the people.

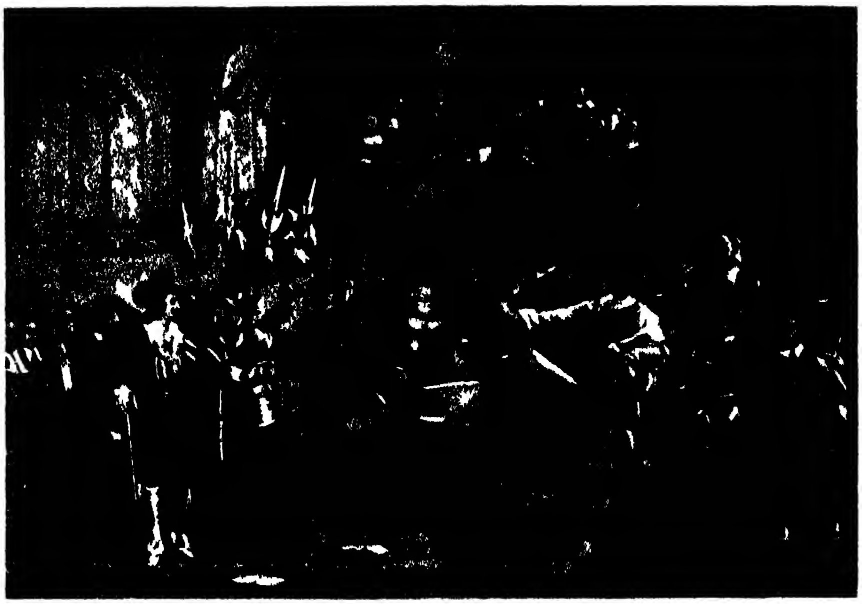
As soon as he came to the throne Charles found himself in need of money, and he therefore called Parliament together and asked the House of Commons to vote a sum of one million pounds. But the Commons had been suffering under many grievances, and realising that if they gave the King at once all the money for which he asked they would get no help from him, they voted him only £150,000 to go on with.

Now it had been the custom when a king or queen mounted the English throne to vote the new sovereign a grant of what was known as Tunnage and Poundage, taxes levied upon every tun of beer or wine and every pound of merchandise imported into the country. We now call these taxes Customs Duties.

When Charles asked Parliament to vote Tunnage and Poundage for life, the Commons declared that they would vote it for one year only, and not for the King's life. Charles was furiously angry, and rather than accept the money on such conditions he refused it altogether. This was rather silly, for he was badly in need of money, and half a loaf is better than no bread.

Charles then did something which made his subjects distrust him greatly. The French King, with his minister Cardinal Richelieu, was besieging his Protestant subjects in the strong town of La Rochelle. Richelieu asked Charles for help, but Charles did not dare to grant it openly, for his English subjects were very anxious to send an expedition to assist the French Protestants or Huguenots.

A fleet of English ships had been gathered in the Channel, and when this sailed it was supposed that they were going to help the Huguenots. But the admiral in command suddenly announced that the King's orders were that they were to fight not for the Huguenots but against them.



The trial of Charles the First. From the painting by J. Burnet

The captains and crews flatly refused to obey these orders, and the admiral had to return to England. Afterwards the fleet was ordered to sail to Dieppe, and the admiral then handed over the ships to the French King's forces. It was a poor beginning for a new reign, and boded ill for peace between the King and his subjects.

But Charles was more badly in need of money than ever, and asked the Parliament to vote him some. The House of Commons declared that their grievances must be redressed before they would vote a penny, so Charles dissolved his first Parliament.

This, however, did not remove his difficulties. Money must be obtained, and so the King, without any authority from Parliament, issued orders under his Great Seal to large numbers of his subjects demanding certain sums from them. In this he was distinctly breaking the law of England, for the Twelfth Article of Magna Carta declares that "No scutage or aid shall be imposed in our kingdom except by the Common Council of the realm." Other laws also confirm this. The people paid, but a bitter spirit began to rise in the nation.

When Charles summoned a second Parliament the first thing the members did was to draw up a fresh list of grievances, adding many new ones to the old, and they pointed out that the King's method of raising money was illegal, and they made attacks on his favourite, the Duke of Buckingham. Charles thereupon did the most foolish thing he could possibly have done: he began to threaten the Commons.

"I will be willing," he replied, "to hear your grievances as my predecessors have been, so that you will apply yourselves to redress grievances and not to inquire after grievances. I must let you know that I will not let any of my servants be questioned by you, much less such as are of eminent place and near to me. I see you specially aim at the Duke of Buckingham. I would you would hasten for my supply, or else it will be worse for yourselves, for if any ill happen I think I shall be the last to feel it."

Supply, it must be explained, is the term used for money voted by Parliament.

The House of Commons at once replied to the King's threat by impeaching Buckingham, that is, they brought charges against him before the House of Lords so that he might be tried. Charles got over the difficulty by dissolving Parliament.

He now began to extort money from all sorts of persons. Tunnage and Poundage dues were collected by the King's orders without the consent of Parliament; seaport towns were compelled to furnish ships or money; Roman Catholics were compelled to pay heavy fines and to serve as soldiers, contrary to the law of the land; and the King and his friends declared that he had a perfect right to do all these things without the consent of Parliament. He and his friends claimed that the King was appointed by God, that he ruled by Divine Right, and that he was not bound to obey the laws made for his subjects.

William Laud, the Bishop of Bath and Wells, who was afterwards appointed Bishop of London and then Archbishop of Canterbury, was one of the King's supporters in this idea.

After the second Parliament had been dissolved five gentlemen were imprisoned by the King's order for refusing to pay the money demanded of them. They declared that by law they were not bound to pay this money, and pointed out that by the Twenty-ninth Article of Magna Carta "No free man shall be taken or imprisoned unless by the lawful judgment of his peers or by the law of the land." However

they were put in prison and were then brought to trial.

In those days judges were not impartial as they are to-day, and no man could rely on receiving a fair trial. The Chief Justice, Sir Nicholas Hyde, who wanted to please the King, declared that the law had not been broken, and that the prisoners, having been arrested by special order of the King, could claim neither to be released nor to be tried.

Here was a fine state of things! For centuries Englishmen had been fighting for liberty and justice, Magna Carta had been looked up to as safeguarding citizens of all ranks, and now it was declared that this was of no value against the King's orders. No wonder feeling against the King grew stronger and became more widespread!

In 1628 Charles was compelled to call a third Parliament, but when he asked for money the same answer was given: the redress of grievances and the granting of supplies must go hand in hand. The House of Commons also drew up a petition to the King, which has come to be known as the Petition of Right. There were many points in it, but the chief were these: that no man should be compelled to pay money to the King without the consent of Parliament, and that no man should be damaged or punished for refusing to pay; that no man should be imprisoned without cause shown; and that in time of peace no one should be punished by martial law.

There was a good deal of argument, but in the end Charles agreed to the Petition of Right. The Commons were delighted, for they trusted the King's word, and they at once voted the money he wanted.

Charles, however, had no intention of carrying out his part of the bargain. He at once declared that Tunnage and Poundage were not taxes, and that he would levy them whatever the House of Commons might say. Of course, the House of Commons protested, and Charles at once prorogued it. Not long afterwards the Duke of Buckingham was assassinated at Portsmouth, as he was about to lead another expedition to La Rochelle, this time to help the Protestants.

It is impossible to describe all the quarrels between Charles and his Parliaments. His third Parliament was dissolved, and then for eleven years he ruled without a Parliament. His chief helper was a former Member of the House of Commons, named Sir Thomas Wentworth, whom Charles made Earl of Strafford. It seemed as though Charles and his friends did everything they possibly could to make enemies of the people. The Roman Catholics and Puritans alike were persecuted. Taxes were levied in such a way as to set aside Magna Carta altogether, and Charles demanded what was called Ship Money, not only from people in seaport towns, but from those inland as well.

A Buckinghamshire gentleman named John Hampden refused to pay the twenty shillings demanded of him on the ground that Parliament had not levied the tax. He was brought to trial and the judges, supporters of the King, declared that he must pay, for no Act of Parliament could take away the power of the King or prevent him from commanding the person, property and money of the people.

Things were fast coming to a head. Charles and his friends became more and more lawless. Archbishop Laud declared that it was wicked and a sin against God to resist the King, no matter what he did.

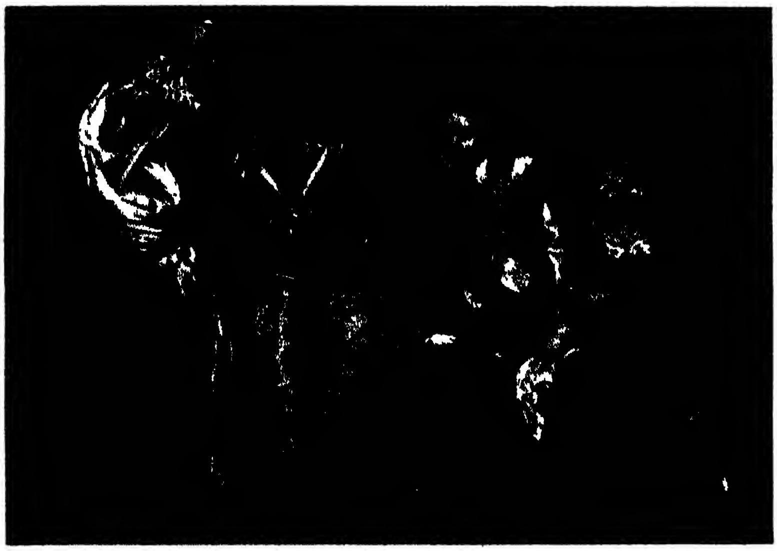
At last, in 1640, Charles was compelled to summon his last Parliament. It was the fifth. There had been four others, all of which had resisted the King's interference with the liberties of his subjects and breaches of the law of England.

The fifth Parliament was no exception. Its first act was to impeach the Earl of Strafford and Archbishop Laud, but it soon changed the impeachment of Strafford for another plan known as a Bill of Attainder. In this scheme no trial was necessary. A Bill was brought into one of the Houses of Parliament, passed through both Houses, and then when the King gave his consent became an Act of

King Charles leaving Westminster Hall after sentence of death had been passed upon him. From the painting by Sir John Gilbert reproduced here by permission of the Mappin Art Gallery, Sheffield

Parliament, and it had to be obeyed as part of the law of the land. The Bill of Attainder declared Strafford guilty of certain crimes, the punishment of which was death. The Bill quickly passed both Houses of Parliament, but Strafford could not die unless the King gave his consent.

Who would have dreamed that Charles, having used Strafford as an instrument for so many years, and having been most loyally and faithfully served by that nobleman, would ever have agreed to his death for doing the King such faithful service? Yet this King, to his everlasting shame, gave his consent and signed his name to the Bill. Strafford died on the scaffold, his head being cut off by the "bright execution ax" which later on was to cut off his treacherous master's head.



Charles the First and Bishop Juxon on the morning of the King's execution. From the painting by S. Blackburn

Charles now went from bad to worse. He went to the House of Commons with a guard of soldiers to arrest five Members, but they had escaped. The King tried to coerce the Commons, and the Commons were more than ever determined to resist the King's attacks on their rights.

It was clear that there could be no settlement of the dispute except by force of arms. And so the King, declaring that his subjects were in rebellion, gathered an army and raised his standard at Nottingham on August 22nd, 1642. This was the beginning of the great Civil War.

Those who fought on the King's side were called Cavaliers, while those on the side of the Parliament were known as Roundheads, because so many of them were Puritans, and instead of wearing long hair like the Cavaliers, had their heads cropped short.

The King himself commanded the Royalist army, and the Earl of Essex that of the Parliament. At first the King's troops gained the advantage. The Cavaliers were fighting for honour, which is a far more inspiring thing to fight for than mere pay. Many of the Parliamentary soldiers at first were merely fighting because they were paid to do so. Further, the King's warriors were men who from boyhood had been trained to the use of arms, whereas the supporters of the Parliament were mostly farmers, merchants, lawyers, shopkeepers and labourers who had had no experience or practice in fighting.

There was in the Parliamentary army, however, an officer named Oliver Cromwell, who realised that something more than paid soldiers were necessary if victory was to be won. "It is plain," he said to his friend, John Hampden, "that men of religion are wanted to withstand these gentlemen of honour," and he began training a body of men who should fight for liberty and faith. These men became the finest soldiers in Europe, and were known as Cromwell's Ironsides. It was they who won battle after battle and finally secured victory for the Parliament.

After one victory Cromwell wrote to a friend: "God hath given the victory to our handful; let us endeavour to keep it. I had rather have a plain russet-coated captain that knows what he fights for and loves what he knows, than that which you call a gentleman and is nothing else. I honour a gentleman that is so indeed."

After being defeated everywhere and losing Oxford, his headquarters, Charles realised that his only chance of defeating the Parliament party was to sow dissension in its ranks. He made peace offers separately to the Parliament and to the Roundhead army, but neither side trusted him, and in despair he fled and gave himself up to a Scottish army which was lying at Newark in Nottinghamshire. He tried to get this army to desert the Parliament, but failed, and eventually the Scottish army sold their prisoner to the English for £400,000. It was a mean thing to do, for Charles was a countryman of theirs.

Differences now arose among the Roundheads, and the Parliament and its army fell out. Charles was held by the army, but still faithless, he tried to treat secretly with all parties, the Scots, the Irish and the Presbyterians. Cromwell, who was now all-powerful, learned of this, and determined that he should be brought to trial.

Charles escaped, but was soon recaptured, and on January 20th, 1649, he was brought to trial for high treason before a High Court of Justice sitting at Westminster.

The charge began as follows: "Charles Stuart, King of England, the Commons of England being deeply sensible of the calamities that have been brought upon this nation, which are fixed upon you as the principal author of them, have resolved to make inquisition for blood; and according to that debt and due they owe to justice, to God, the kingdom and themselves, they have resolved to bring you to trial and judgment; and for that purpose have constituted this High Court of Justice before which you are brought."

The charge then went on to state that Charles, out of wicked design to uphold unlimited and tyrannical power and to overthrow the rights and liberties of his people, had treacherously and wickedly levied war against the Parliament and the people. The charge concluded by declaring that the Commonwealth had "for the said treasons and crimes impeached the said Charles Stuart as a tyrant, traitor, murderer and a public and implacable enemy to the Commonwealth of England, and prayed that he might be put to answer the premises and that such proceedings should be had as were agreeable to justice."

The King sat apparently unmoved till he was described as "a tyrant, traitor, murderer," and so on, and then he laughed.

Charles bore himself with courage and dignity, and he at once disputed the legality of the Court. "It is not," he said, "my case alone, it is the freedom and liberty of the people of England; for if power without law may make laws I do not know what subject can be sure of his life or anything that he calls his own."

These were admirable sentiments, but Charles should have thought of them during the previous twenty years, instead of repeatedly and constantly breaking the law, and thereby setting a precedent for his judges.

There was a long wrangle as to the right of the Court to judge the King, and the proceedings were adjourned. As the King left the Court in charge of his guards there were cries of "God save the King!" His dignified bearing had drawn forth the admiration of many beholders.

When the Court met again it declared itself competent to try the King, but Charles said he would answer the charges as soon as he knew by what authority the Court acted. Again a long argument followed, and once more the Court adjourned.

After other meetings it was decided to take evidence against the King, and

a number of witnesses told how he had raised his standard and gathered an army Finally, on January 27th, the Court met and Charles was declared guilty of the crimes laid against him and the sentence was given "For all which treasons and crimes this Court doth adjudge that he, the said Charles Stuart, as a tyrant, traitor, murderer and public enemy to the good people of this nation, shall be put to death by severing his head from his body"

During the reading of the sentence the King smiled, and then asked permission to speak, but the Court refused this, at which the King replied "I am not suffered to speak Expect what justice the people will have!"

The trial was not such as would be regarded as a fair trial to-day but neither was any trial in those days Judges were almost always partial and if it was desired to find a man guilty the evidence was always sifted so as to bring about the desired result

Charles was no more a martyr than any other prisoner of his time It was simply a case of a law-breaker being condemned by law-breakers Two wrongs of course never make a right but Charles himself, it must always be remembered, had set the fashion in law breaking The men who tried him were originally loyal and law abiding citizens till goaded into rebellion by the injustice of the King

On the evening of the day on which he received sentence the King sent a message to the Commissioners asking that he might see his children and that Dr Juxon, Bishop of London might attend to pray with him The requests were granted Only two of his children were in London, the others having escaped

Charles had a long tender and affecting interview with Princess Elizabeth, then about thirteen, and Henry, the little Duke of Gloucester, who was about seven He bade the Princess Elizabeth tell her mother that his thoughts had never strayed from her, and that his love would be the same to the last, and begged her to remember to tell her brother James whenever she should see him, "that it was his father's last desire that after his death he should no longer look on his brother Charles merely as his elder brother but should be obedient to him as his sovereign, and that they should both love one another and forgive their father's enemies"

"I will never forget it as long as I live," replied the little princess

Charles prayed her not to grieve for him, for he should die a glorious death, it being for the laws and liberties of the land He charged her to forgive those people who had condemned him, but never to trust them, for they had been most false to him, and to those that gave them power Strange words from one of Charles's faithlessness!

Then, taking the Duke of Gloucester on his knee, the King said to him "Sweetheart, now they will cut off thy father's head Mark child what I say they will cut off my head, and perhaps make thee a king but mark me, you must not be a king so long as your brothers Charles and James do live," at which the child said earnestly, "I will be torn in pieces first"

King Charles on his way to the scaffold outside the Banqueting Hall, Whitehall From the painting by G Wappers

Then came the parting, when the King commanded them both to be obedient to their mother, and bade the Princess Elizabeth to give his blessing to the rest of her brothers and sisters

The execution was fixed for January 30th, 1649 It was a snowy day, and the King, attended by Bishop Juxon, went to the place of execution, a scaffold erected outside the Banqueting Hall in Whitehall, now the Royal United Service Institution

"There is but one stage more," said Juxon to the King, 'which, though turbulent and troublesome, is yet a very short one Consider, it will carry you a great way —even from earth to heaven"

"I go," replied the King, "from a corruptible crown to an incorruptible where no disturbance can take place"

Then the King said to the executioner, "Is my hair well?" removed his cloak doublet and waistcoat and said "When I put out my hands this way," stretching them out 'then——' He did not finish the sentence but apparently raised his hands and eyes in prayer

The next moment he laid his neck upon the block, and when the executioner put his hair under a cap the King, thinking he was going to strike said "Stay for the sign" After a pause the King stretched out his hands, and with one blow the executioner severed his head from his body Holding it up before the people he said "Behold the head of a traitor!"

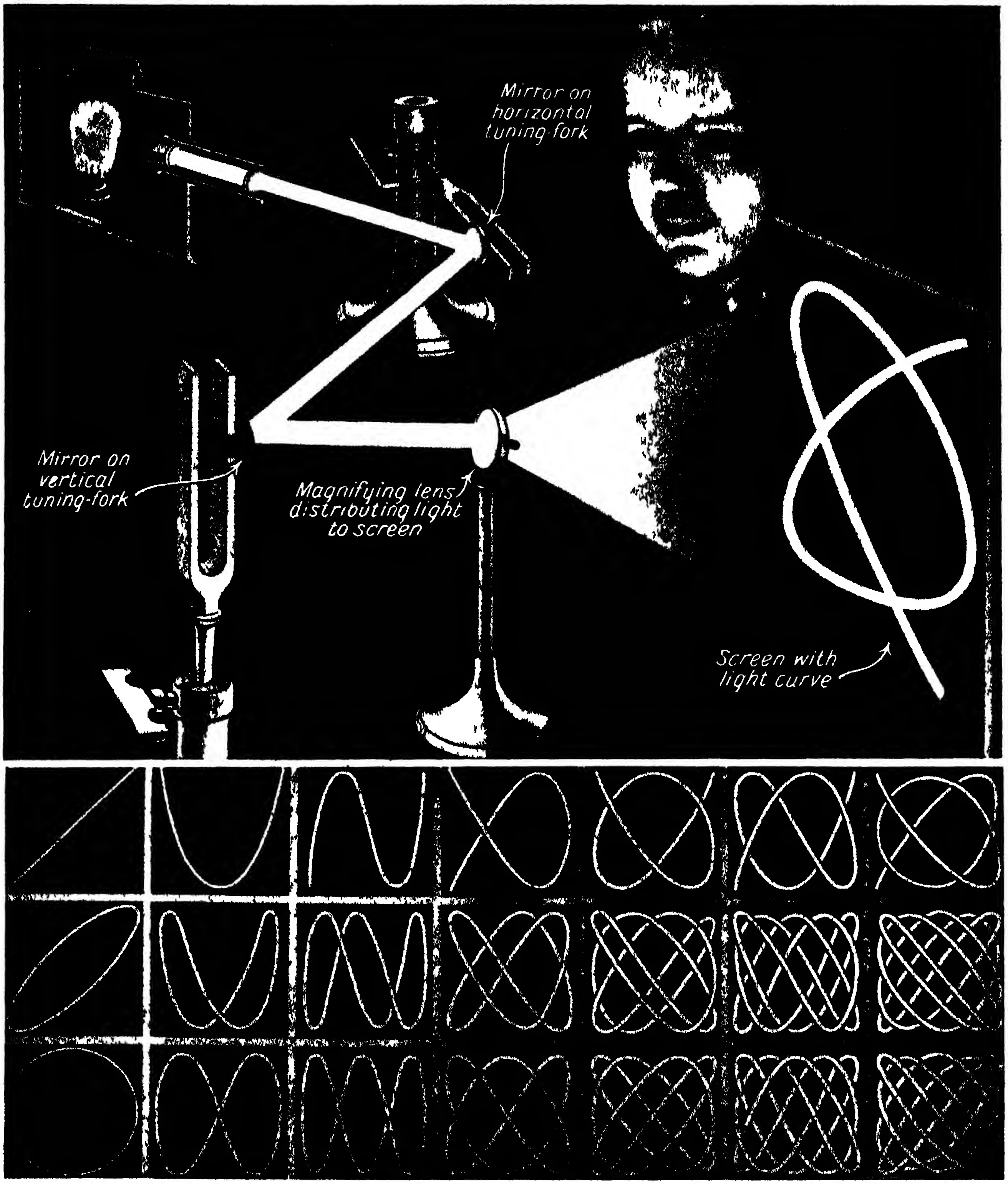
There was a groan from the spectators for Charles by his quiet dignity had gained much sympathy Then soldiers came and cleared the street The body was put into a coffin, and a week later was borne to Windsor and buried in Henry VIII's vault

It is often suggested that Charles died for some high principle — the Divine Right of Kings which the poet Pope calls 'the right divine of kings to govern wrong" But such is not the case Charles's quarrel with his people was a much more sordid one than that He was quite ready to acknowledge and govern by means of Parliament provided Parliament would pay him all the money he asked for When he could not get money he claimed the Divine Right to take it from his subjects without Parliament's consent

So far as the King was concerned the Civil War was a fight for money So far as the Parliament party was concerned it was a fight for liberty, and it is well that we should remember this For the liberty which we enjoy to-day and the happy Constitution under which we live with King Lords and Commons all working harmoniously together is largely due to what happened in Charles the First's day

The late Lord Morley put the matter clearly when he wrote "The two most sensible things to be said about the trial and execution of Charles I have often been said before One is that the proceeding was an act of war, and was just as defensible or just as assailable, and on the same grounds, as the war itself The other remark, thought tolerably conclusive alike by Milton and Voltaire, is that the regicides treated Charles precisely as Charles, if he had won the game, undoubtedly promised himself with law or without law he would treat them From the first it had been 'My head or thy head,' and Charles had lost"

HOW SOUNDS ARE MADE VISIBLE TO THE EYE



It is possible to make sounds visible to the eye, and the method is shown on this page In the upper part of the picture we see two tuning-forks to which have been attached small mirrors One of these forks is placed in a stand horizontally, while the other stands vertically A powerful beam of light is made to shine into the mirror of the horizontal tuning-fork, and the vertical fork is so placed that the light is reflected into its mirror from the first mirror, and thence passed through a lens so as to shine upon a screen If now the horizontal tuning-fork be sounded while the second fork remains at rest, the light on the screen becomes a beautiful luminous streak When the vertical tuning-fork is also sounded in unison with the other, the straight line of light on the screen becomes a bright curve. If, now, a piece of wax be fastened to one of the tuning-forks so that there is a slight difference in its vibration, the luminous figure on the screen will be changed and pass through many variations When there is a difference of an octave between the tuning-forks the curves on the screen become very complex The lower part of this picture shows some of the remarkable variations that are presented

WHY THE BELLOWS MAKE THE FIRE BURN

A pair of bellows was once a familiar domestic object seen in every home, but nowadays it is not seen so often, because in towns at any rate so many houses are heated entirely by gas or electricity. It is, however, a very useful device, and in its larger forms in blacksmiths' shops and foundries is very necessary. On this page will be found many interesting facts about the bellows.

EVERYONE knows that if the fire has burnt low and we blow the embers with a pair of bellows the fire will soon revive and burn brightly. We know also that the blacksmith gets his fire to burn with an intense heat by working his bellows. Before long the fire is roaring so that he can use it for heating his ironwork.

Why is it that the bellows make the fire burn more fiercely? It is because the constant stream of air supplies more oxygen to the fire, and it is oxygen that aids combustion. If the oxygen were cut off altogether the fire would die down and eventually go out. By passing a constant stream of oxygen through the burning fuel the combustion is helped enormously, and so what was a dull fire soon becomes a roaring furnace.

Bellows are a very old device for making a fire burn brightly. We find pictures of Egyptians using bellows on the tombs of Ancient Egypt, and in one of these dating back to 1400 B.C. the bellows are shown as a pair of leather bags or cylinders attached to discs.

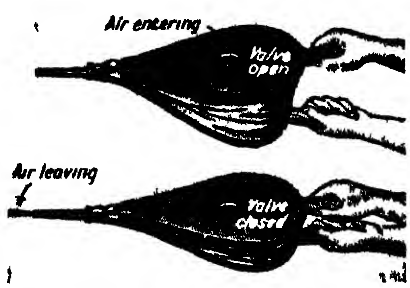
These are alternately inflated and compressed, men working them with their feet and hands, throwing the weight on the different bags alternately, and lifting the one just exhausted by means of a cord. A pipe carries the air to the fire, in which a man is holding a rod of metal.

The Greeks and Romans also used bellows, consisting of two boards joined by a piece of leather. Even in the Bible we find a reference to the bellows, for Jeremiah (Chapter VI, verse 29) speaks of the bellows in the foundry being burned. All nations seem to have used the bellows. For centuries they have been known in China, Japan, India, Africa and America.

No one can say who invented this useful device, but he was certainly a great benefactor of his fellows, and the development of the bellows in modern days is found in the hot and cold air blasts of the iron and steel foundry.

In their simplest form the bellows consist of two flat boards, generally triangular in shape, each with a projecting handle. Between the boards are two or more hoops bent to the shape of the bellows, and a piece of leather is nailed to the edges of the boards, partly enfolding the hoops and forming an enclosed chamber, which is enlarged or contracted by raising the upper board while the lower one remains stationary.

There is a valve in one of the boards consisting of a hole with a leather flap. When the bellows are opened the pressure of the air outside pushes down the valve and enters the chamber. Then when the boards are closed together by means of the handles the pressure of the air inside pushes up the leather flap and closes the valve; the air then escapes through the nozzle at the narrow end.



When the domestic bellows are opened air enters from outside to fill the space caused by the separating of the two boards. When the boards are closed the pressure of the air inside closes the valve by pressing up the leather flap, and the air is thus forced to go out through the nozzle

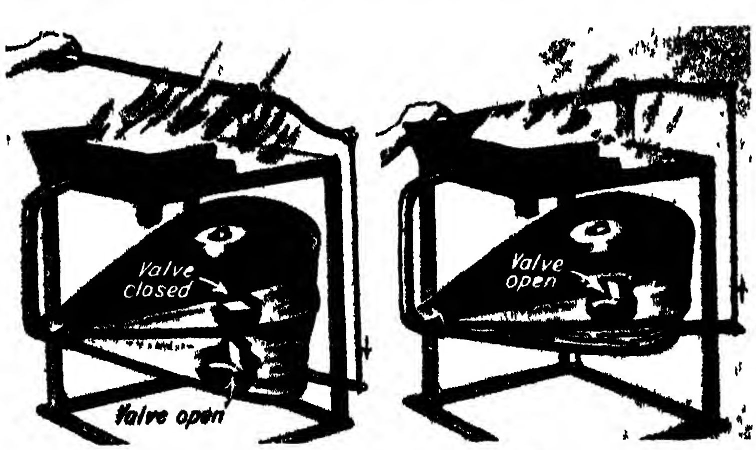
The bellows are made of a triangular shape because the air as it goes towards the nozzle when the boards are being closed is pressed into an ever-decreasing space, and thus the force of the blast is strengthened, for when a given quantity of fluid has to pass through a narrower channel, the force is increased.

The bellows used by the smith are furnished with a third board of the same shape as the others. This divides the bellows into two smaller chambers, connected by a valve opening upward. When the handle is depressed the lower board is raised and the air in the lower chamber is forced through the valve in the middle board, filling the upper chamber. The top board, which is weighted, descends, forcing the air out through a pipe to the fire on the forge hearth. Then when the handle is raised again and the lower board descends, air enters through the valve, filling the lower chamber ready for the next blow.

Of course, there are various forms of forge bellows, some more powerful and on a larger scale than the one shown in the picture, and sometimes these are fixed and sometimes portable.

The form of the domestic bellows used to-day is by no means a modern one, for an old Roman lamp has come down to us made in the shape of a man with bellows, and these bellows are exactly like the ones which are seen to-day.

Of course for large forges the bellows are not worked by hand or foot, but by a mechanical device, and in the most up-to-date shops, instead of bellows of the form shown, the fire is blown up by an electric fan, which is set in operation by the moving of a switch. It is, of course, far more compact than the bellows, occupying less room, and it has the additional advantage of getting to work instantaneously as soon as the blacksmith moves the switch.



The blacksmith's bellows are like the domestic variety, only there is a third board dividing the bellows into two chambers. When the handle is raised the lower board is depressed and air enters through a valve. Then when the handle is pressed down, as on the right, the lower board is brought up, driving the air into the upper chamber and the weight of the upper board causes it to descend, driving the air through a pipe to the fire

EXPERIMENTS IN FORMING CRYSTALS

Many substances when they become solid or when they are deposited as a solid from a solution form as crystals that is, they take a formation in which they have definite shapes, faces and angles. Different substances in the crystalline state have different geometrical forms but the same substance always takes

Salt crystals produced by evaporating brine

the same form and a small crystal of it is the same shape as a large one. Thus common salt always crystallises in the form of a cube.

We can carry out a number of experiments in making crystals for ourselves. Substances like salt and sugar and alum and soda and bluestone or copper sulphate may all be dissolved in water and then produced as definite crystals by hanging in the solution a piece of string or thread. As the water evaporates the substance is deposited upon the string in its own particular form of crystal.

Perhaps the simplest of all crystal experiments is to dissolve common salt in water and then pour some of this solution

Alum crystals on a window pane

into a plate or saucer, leaving it on a hob or some place where the water can be made to evaporate quickly. If we examine what is left through a reading-glass or other magnifying lens we shall find that the salt is in the form of small crystals which are cubes in shape. Some will be large enough to see with the naked eye.

Another very interesting experiment is to form crystals on the window-pane very much in the same way as Jack Frost does when he freezes the water vapour that we breathe out. We get a similar effect by brushing over the glass a warm solution of some crystalline substance, such as alum or Epsom salts. When the solution cools and the water evaporates crystals form on the glass, giving it the frosted appearance that is so familiar in cold weather. A little size added to the liquid will make the crystals adhere more firmly to the glass so that they will not so easily be rubbed off.

Sometimes a saturated solution can be cooled down completely without depositing crystals. Here is an interesting experiment in connection with this matter. Make a solution of sulphate of sodium, commonly known as Glauber salts, by adding more and more to boiling water in a clean glass flask until the water will take up no

Crystals forming round particles of dust as soon as the flask is unstopped

more in solution. Close the mouth of the flask with a lump of cotton-wool, so that no dust can fall in. Be very careful that the flask is not shaken in any way. The solution will cool right down without any crystals forming.

Now remove the cotton-wool stopper, and probably as particles of dust fall into the bottle crystals will form round them, the dust acting as a nucleus. Then crystallisation will go on with amazing rapidity. Anything put into the bottle, such as a piece of wool, or a stone, or a stick, will start crystallisation.

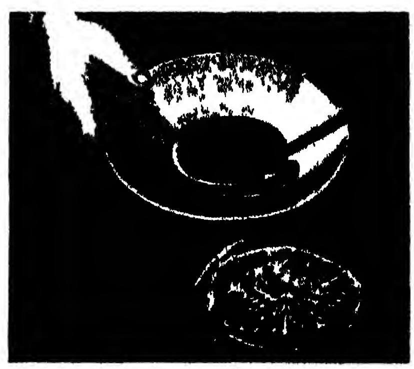
Crystal baskets and crowns can be made by bending wire into the shape of these objects, binding them round with cotton, and placing them in a saturated solution of alum. If they are allowed to stand for some days, they will become covered all over with crystals, and the crystals will, of course, grow larger the longer the wire-work is allowed to remain immersed.

Even a substance like sulphur may be crystallised. We place some roll brimstone in a vessel and melt it with a gentle heat, being very careful that it does not catch fire. Now place it where it can get cool, and as soon as a crust forms on the surface take an iron skewer or knitting-needle and poke two holes in the crust on opposite sides

Wire shapes to be coated with crystals

near the edge of the pan. Next tilt the vessel so that the liquid sulphur under the crust may run out through one hole, air entering by the other. As soon as the sulphur has completely cooled the crust can be removed and we shall find that the sulphur underneath has formed tiny needle-shaped crystals.

There are six main systems of crystals distinguished by the way in which their axes or the imaginary lines round which they are built up are arranged. In the cubic system there are three axes of equal length all intersecting at right angles. Then there is the tetragonal system, also with three axes intersecting at right angles, but with one longer or shorter



The formation of sulphur crystals

than the other two. In the rhombic system the three axes are all of different lengths. The hexagonal system has four axes, three being of equal length. In the monoclinic and triclinic systems there are three axes of unequal lengths crossing at different angles.

WHAT MAKES THE COLOUR OF THE SEA

Why does the sea sometimes look blue and sometimes green? Various causes contribute to the colour of sea-water and these are discussed on this page. The effect which the reflection of the sky has upon the apparent colour of the water, and which is often noticed by visitors to the seaside, is also described

How varied is the colour of the sea! Generally, we think of the sea as green, but in some parts when we look down it is a rich blue, and in shallow water with a sandy bottom it is sometimes yellow. Then, again, in dull, cloudy weather it is grey or almost black. Why is it that the water shows such varied colours?

Well, there are many things which contribute to the colour of the sea. Some of the colour is due to the reflection of the sky in the water, and this is particularly the case in dull weather. The dark clouds above reflected in the sea make it look very grey and dull.

But there are other causes of colour besides the reflection of the sky. Many of the variations of colour are due to the small particles of solid matter in the water and to microscopic animals and plants. The saltness of the sea too has a great deal to do with its colour. It is bluer where the saltness is great, so that inland seas, like the Mediterranean, which are salter than the open ocean, are of a richer and deeper blue.

Green Seas

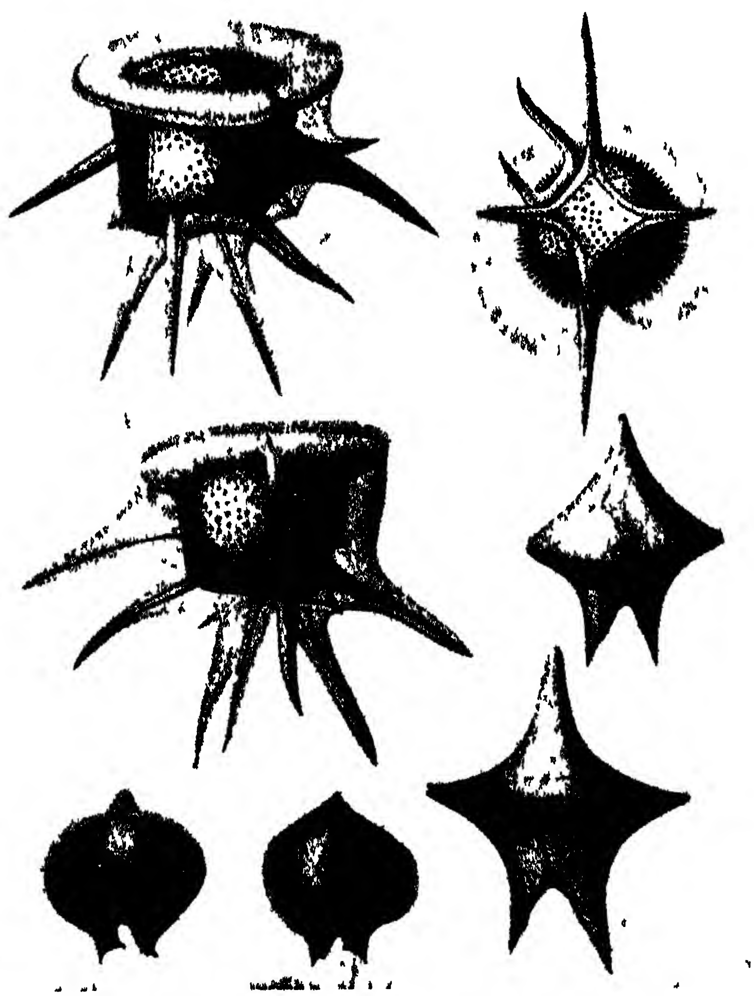
In the Arctic and Antarctic, where, owing to the fresh water the sea is less salt, the colour is far greener. The green is partly due to the microscopic life in the water, and it is also due to some extent in shallow waters to the reflected light of the blue sky being mingled with the yellowish shades of sand and rock on the sea bottom.

The salts and minerals in the sea rarely amount to more than one-fortieth of the total weight of the water, and therefore, where the colour is due to these substances, it is clear that the deeper the sea happens to be the deeper is the colour as we look down into its depths because then we are looking through more water. Actually, the water has very little colour, as we know when we see a bath of sea-water.

The very latest investigations made by a German chemist, Richard Willstatter, suggest that the blue colour of the sea is partly due to the presence in it of dissolved copper compounds. We all know that copper sulphate or blue vitriol, as it is sometimes called, is blue, and the German scientist believes that just as this substance dissolved in water makes the liquid blue, so the copper compounds in salt water give it its blue colour when large quantities of water are seen together.

Taking it all round, however, probably the sea owes more to the reflection of the sky for its colour than to any other cause.

The Gulf Stream off the eastern coast of the United States, is of a very deep indigo blue colour due to the fact that the great evaporation in the Gulf of Mexico causes the water there to be salter than in other parts of the ocean. The Gulf of Mexico in the New World really corresponds to the Mediterranean in the Old World. So blue is the water of the Gulf Stream that it can easily be distinguished by its colour alone from the other water of the ocean amid which it flows.



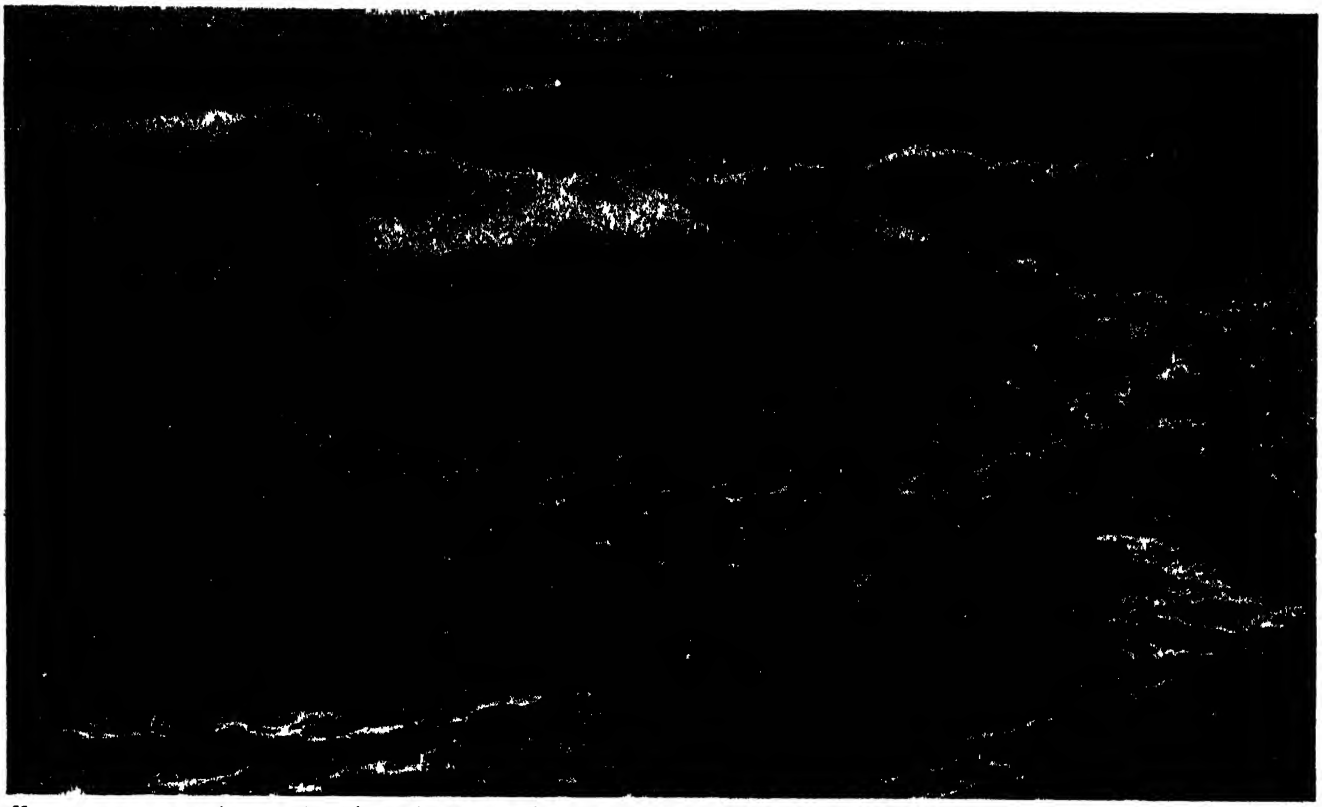
Some of the exceedingly tiny forms of vegetable life found in the sea, which help to give the water a green colour. These plants are known as diatoms, and this picture, which is reproduced by courtesy of the Carnegie Institution of Washington, shows them enormously magnified

The Blue Red Sea

The Red Sea is quite a misnomer for, despite its name, it is a very deep blue in its deepest parts. The reddish hue of the water is only to be seen along the shores on either side where the coral reefs a little way down and the abundance of microscopic animal life give it its reddish tinge. Sometimes a river will carry down a vast amount of muddy sediment and this will give the sea for hundreds of miles a yellowish colour. This is the case with the great rivers of China, and explains the name of the sea into which they run—the Yellow Sea.

Sometimes the colour of the sea is streaky, blue and green alternating. This is often noticeable in the Greenland Seas, and is due to an abundance of minute animal life appearing in long strips at intervals.

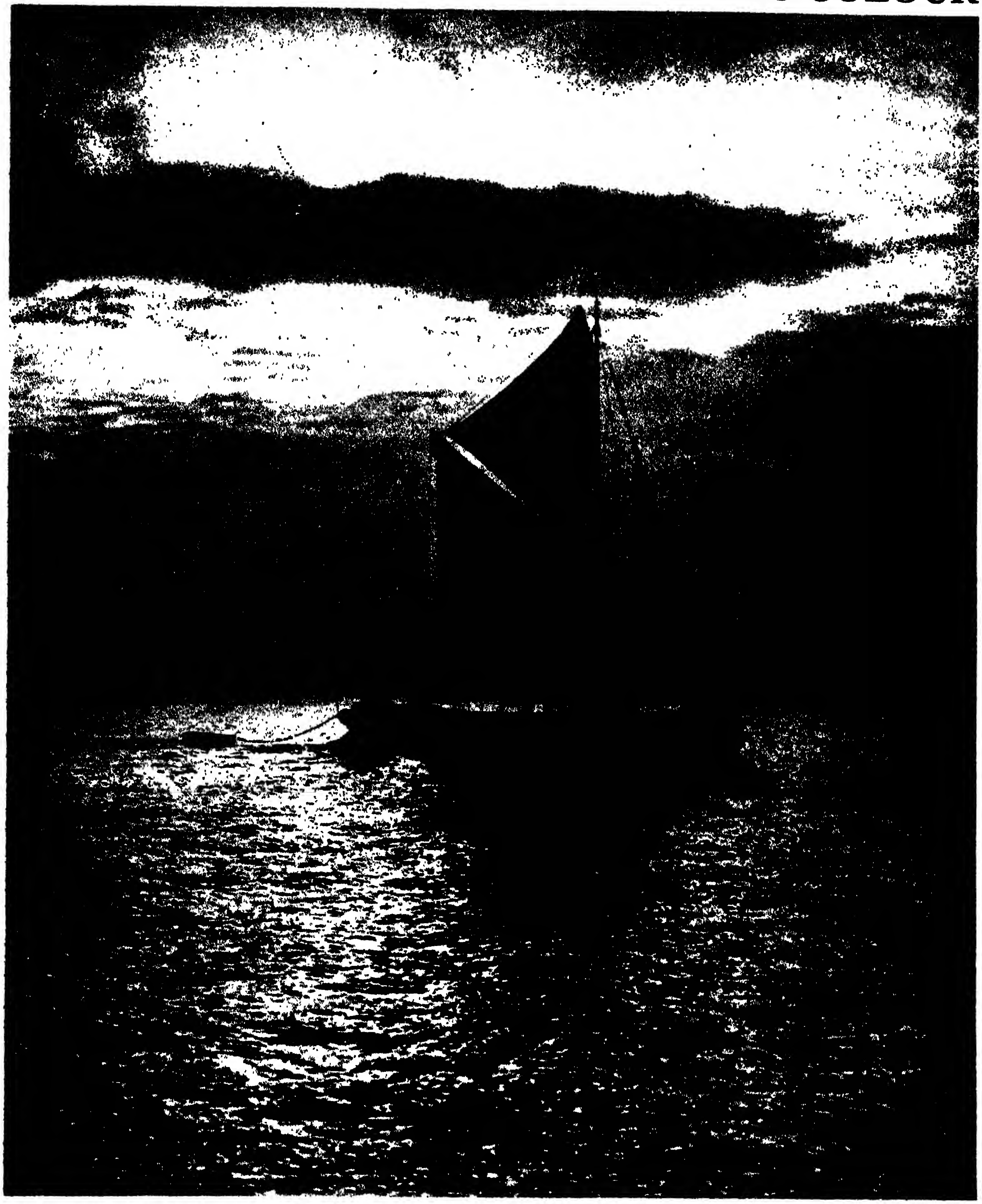
WHY DIFFERENT SEAS VARY IN COLOUR



Various causes contribute to the colour of the sea For example, the North Atlantic is generally a grey-green due to the microscopic life brought to it by the Gulf Stream and also because of the heavy swells which keep the water in constant movement There are also considerable cloud banks over the Atlantic and these, by their reflection, tend to darken the water

The saltier the sea, the more blue is its colour That is why the Mediterranean, seen here off Cannes on the French coast, is much more blue than the Atlantic Ocean The Mediterranean, a land-locked sea, is much saltier than open seas because few rivers flow into it

HOW THE CLOUDS AFFECT THE SEA'S COLOUR



The colour of the sea is due not only to the salt and other minerals in it, but also to minute creatures which live in its waters and give a deep green tinge to them. If the sea is shallow the colour of the bed also affects the appearance of the water. A great deal of the colour of the sea, however, is due to the reflection of the sky, as we may see for ourselves next time we visit the seaside. With a clear, rich blue sky the sea itself often looks very blue, except where it is shallow and has a sandy bottom. In that case the blue reflection of the sky, mingled with the yellow of the sand, gives a green appearance. Clouds greatly affect the appearance of the sea. When they are dark, the sea appears almost black, and clouds crossing the sky cause the sea to change in colour almost every minute

THE GREAT MYSTERY OF THE HAILSTONES

Hail is one of the greatest mysteries of the weather, for no scientist can tell us definitely how the hailstones are formed. Snow and rain perform useful services for man and beast, but hail does harm wherever it falls, beating down crops and often doing great damage to windows, glass-houses and animals. Here are many interesting facts about the hail

It seems a strange thing that men of science who can explain to us quite clearly how rain and snow are formed do not know how the hailstones come into being.

They are usually spoken of as frozen raindrops, but this cannot be a true or full explanation, for they are generally much larger than any raindrop can ever be, and when they are cut open they frequently show that they have been formed in layers round a nucleus, although sometimes they are quite different and seem to have rays or lines passing from the centre to the outside.

We know that rain is formed when a mass of air is cooled below a certain temperature and some of its moisture is condensed into little drops of water that at first hang in the air as cloud and then when they are too heavy to be suspended longer, fall as raindrops. Snow, too, is known to be water vapour that condenses directly into little crystals of ice, without having become first of all drops of water. The little crystals unite and become flakes of snow

Pellets of Ice

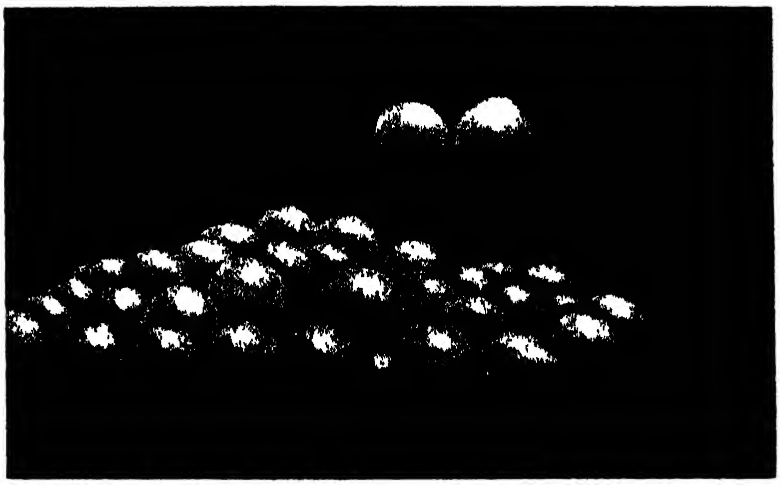
But how can the hail be formed? Hailstones are really pellets of ice and their history is believed to be as follows. They generally fall during a thunderstorm and it is thought that electricity has something to do with their building up. They are formed in columns of rapidly ascending air and probably begin as raindrops. But owing to the upward current they are unable to fall, and so are carried up to a region where the temperature is below freezing point. The raindrops become tiny pellets of ice and as the updraught continues several may be frozen together.

Sooner or later the ice-pellets get blown into a weaker updraught and then they fall back into warmer regions below where they gather a fresh coating of water, condensed from the vapour. But this at once freezes owing to the coldness of the kernel of ice round which it has gathered.

Again the hailstone meets an upward gust and is carried up once more into colder regions, where it probably gathers a coating of snow, that is of ice crystals frozen directly from the vapour. So the up and down journey may be continued, the hailstone gathering more and more coatings of ice, till at last it becomes heavy and falls.

This is quite a reasonable explanation of the formation of ordinary hailstones such as we often see falling in England, but it is not altogether an adequate explanation of the huge hailstones that sometimes fall and do such immense damage. The updraughts would have to be very powerful indeed to carry up and support stones weighing a pound or more.

We all know the story in the book of Exodus of the plague of hail in Egypt which tells us that "there was hail, and fire mingled with the hail, very grievous, such as there was none like it in all the land of Egypt since it became a nation. And the hail smote throughout all the land of Egypt all that was in the field, both man and beast; and the hail smote every herb of the field, and brake every tree of the field."



Hailstones as large as goose eggs that fell at Bagdad, when the ground temperature was 95 degrees in the shade

Some people think such a story of hail killing men and animals to be an exaggeration, but there are other cases on record of terrific hailstorms with stones so big and heavy that they killed man and beast.

The great scientist Charles Darwin tells of a terrific hailstorm that occurred while he was in South America during his voyage in the *Beagle*. It was in the Pampas of Buenos Ayres, and animals as big as deer were killed.

"We are here," says Darwin, "told a fact which I would not have credited if I had not had partly ocular proof of it, namely, that, during the previous night, hail as large as small apples and extremely hard had fallen with such violence as to kill the greater number of the wild animals.

"One of the men had already found thirteen deer lying dead, and I saw their fresh hides; another of the party, a few minutes after my arrival, brought in seven more. Now I well know that one man without dogs could hardly have killed seven deer in a week. The men believed they had seen about fifteen dead ostriches (part of one of which we had for dinner); and they said that several were running about evidently blind in one eye.

"Numbers of smaller birds, as ducks, hawks and partridges, were killed. I saw one of the latter with a black mark on its back, as if it had been struck with a paving-stone. A fence of thistle-stalks round the hovel was nearly broken down, and my informer, putting his head out to see what was the matter, received a severe cut, and now wore a bandage."

Darwin goes on to tell us of other heavy hailstorms, one farther north in the Argentine, where vast numbers of cattle were killed, and one in India in 1831, where many birds were killed and cattle injured. The hailstones in the Indian storm were flat and one was ten inches in circumference, while another weighed two ounces. They ploughed up a gravel walk like musket-balls, and passed through glass windows, making round holes, but not cracking them.

Serious Damage

In November, 1880, there was a heavy hailstorm at Louth, in New South Wales, where stones as large as cricket balls fell in the streets. Nearly every window in the town was broken; and the new galvanised iron roof of a hall and the iron roofs of other buildings were perforated all over. Many dogs and other animals in the streets were killed and gardens were stripped of every vestige of fruit, flower and leaf. A man attempting to cross the street at the height of the storm was knocked down by the hailstones.

In 1888 a still more disastrous hailstorm occured in Delhi and Moradabad in North-West India. Hailstones both oval and flat in form were picked up, and it is said that some weighed as much as two pounds. Probably these were accumulations of hailstones that had become frozen together after falling. But that the stones must have been of huge size was proved by the fact that at least 150 people were killed in the storm.

In 1788 a terrific hailstorm swept over a large part of France and Belgium and carried its ruin into Germany. It seems to have travelled in two parallel strips, varying in width from seven to twelve miles, and separated by a belt of fifteen miles, where it merely rained.

The storm moved at the rate of nearly forty miles an hour, and the hail never fell for more than about seven or eight minutes in any one place. Some of the hailstones were circular and others angular, and the heaviest weighed half a pound. In France alone over a thousand parishes were devastated, and the damage done by the hail was officially estimated at a million pounds.

Another hailstorm in Würtemberg in 1873 extended its ravages over nearly 190,000 acres and caused a loss of nearly a million pounds. In 1932 a hailstorm in the Lea Valley of Essex did enormous damage by smashing thousands of panes of glass in the greenhouses that abound in this district. In another storm at Richmond in Yorkshire, in 1920, hailstones from six to seven inches in diameter were picked up from the ground.

Rain and snow are in most cases useful, but hail is at all times and in all circumstances a baneful and unwelcome visitor. It has been said that no good office can be pleaded in favour of it and that is true, for it renders no useful service and does much damage. At the same time it is one of the greatest enigmas among physical phenomena. No meteorologist can explain the formation of hail satisfactorily.

THE DRIFTING OF THE EARTH'S CONTINENTS

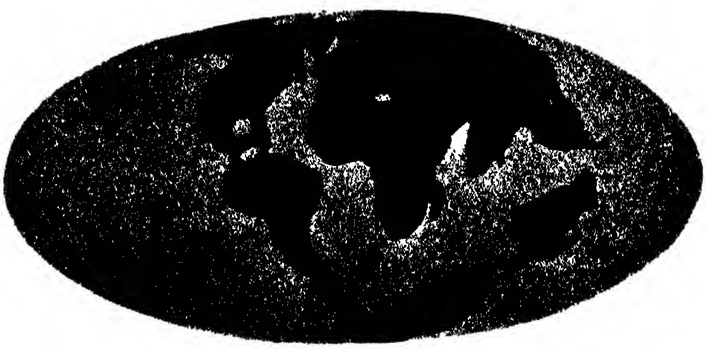
Any thoughtful person who has carefully examined a map of the world must have noticed how curiously the bulge on the north-west part of Africa seems to fit the space between North and South America now occupied by the Gulf of Mexico and the Caribbean Sea. Further, the part of the east coast of Brazil which juts out into the Atlantic seems to fit the Gulf of Guinea on the west coast of Africa. Then Greenland seems to have been cut out to the right shape to fit between North America and the west of Europe.

These facts have led some geologists, including the late Professor Alfred Wegener, to suppose that the continents of the Earth were once all joined together, and that in course of time they have drifted apart. With America brought close to Europe and Africa and Greenland, these continents would fit very well together like a jigsaw puzzle and form one united mass of land. Then one can imagine Australia being fitted round India, with the southern part of India filling up the Gulf of Carpentaria.

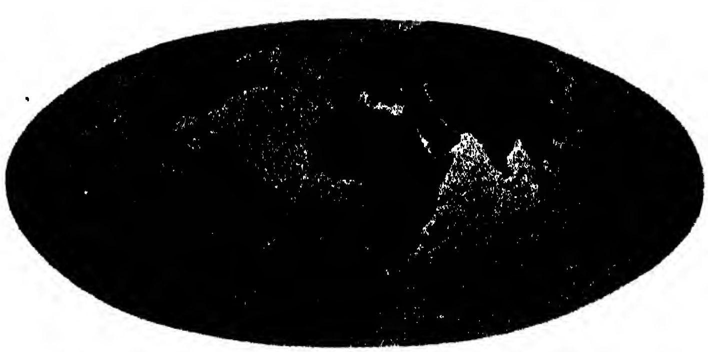
It is a very interesting theory, and those geologists who think that it is a correct explanation of the shapes of the continents believe that the Earth's crust is not rigid, but that the part of its surface which we know as the land drifts or slides over the more rigid material below.

Such a theory would explain many things—as, for example, the fact that Southern India was once covered with a heavy shroud of ice, as Antarctica is to-day. This would be about the time that the coalfields of North America, Great Britain, Europe and China were being completed.

The land surface of the Earth as it possibly appeared 200,000,000 years ago. We can see that the continents were totally different from now



The land surface of the Earth as it is thought to have appeared about 3,000,000 years ago



The land surface of the Earth as it is to-day. In all these pictures the black portion represents the land and the medium shade the shallow seas, while the lighter part is the deep ocean

Ice sheets must have buried parts of South America, South Africa and Australia at the same period, and all this seemed very perplexing and difficult to explain until Professor Wegener suggested that these various lands now scattered in the oceans were then joined together into one huge continent. India would then have been far to the south of where it now is, and the coast of Natal would have been near the South Pole, while the region which is now the North Pole must then have been in the Pacific.

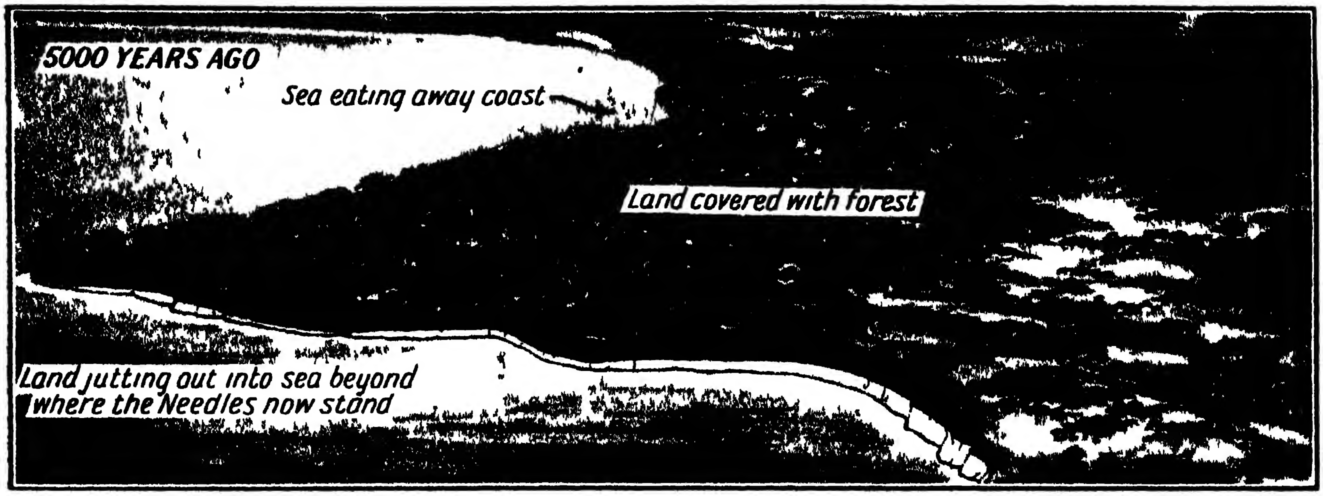
Many geologists think that the shrinking of the Earth through cooling has been quite incapable of causing this separation of the continents.

The two upper maps given on this page show the land part of the Earth's surface as it is believed to have appeared in past ages. The lower map shows it as it is now.

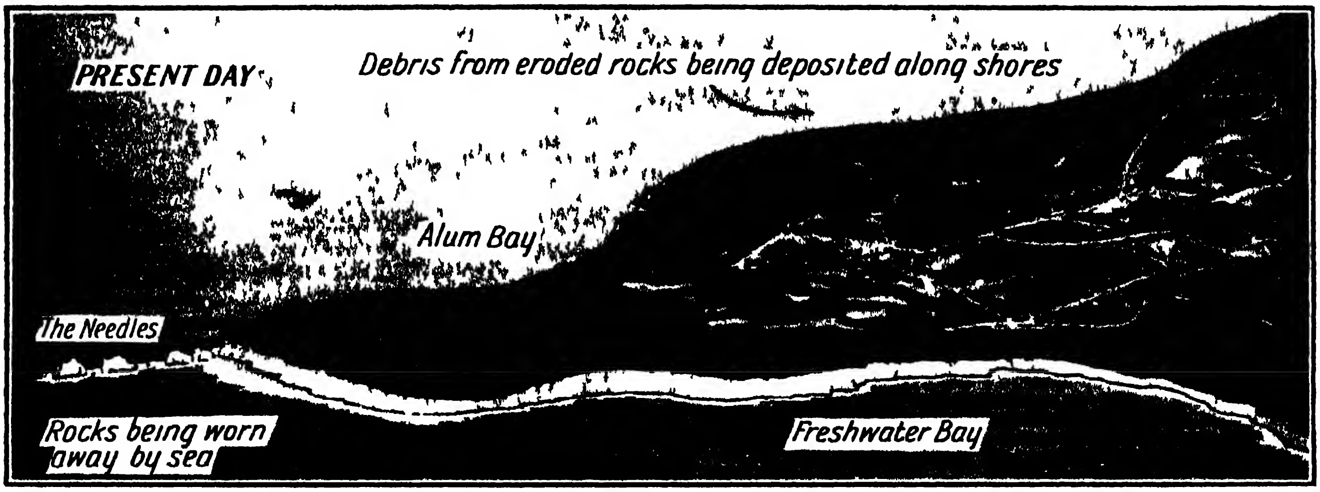
It seems a startling theory to think of the huge continents sliding or drifting over their foundations; but distinguished geologists say there is nothing at all impossible in the theory from a mechanical point of view, and the fossilised remains of creatures which have been dug up in the various continents certainly suggest that in past ages there were land connections between them.

It is rather interesting and curious to note that while Professor Wegener only announced his theory about 1915, the idea was not new or original, for somewhere about 1870 a book of popular science published for boys and girls declared this very theory of continental drift.

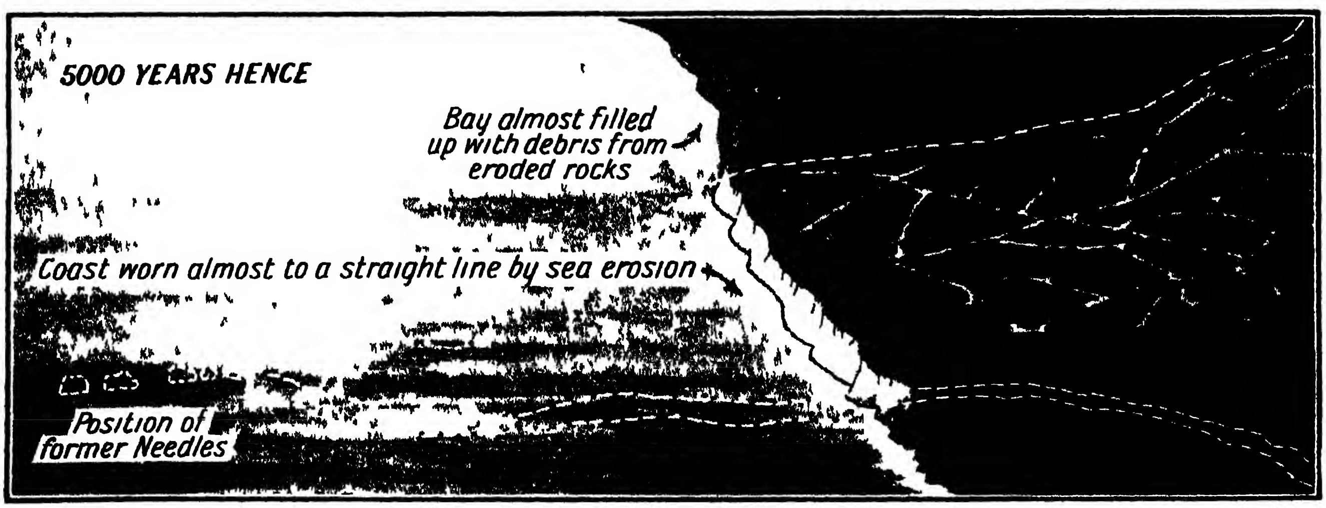
THE STORY OF THE ISLE OF WIGHT FOR 10,000 YEARS



The story of every country's coastline is one of alternate sinking and rising and of erosion and building up. On many parts of the East Coast of England the sea has for centuries been eating into the land, and recent falls of cliff at Cromer show that this is still going on. In other parts, shingle and sand are being added to the coast. The story of the western part of the Isle of Wight illustrates what is going on in so many parts. Here we see the region of the Needles as it must have appeared, say, five thousand years ago



In this picture we see the western extremity of the Isle of Wight as it appears to-day. The sea, during the past few thousand years has been eating away at the cliff, breaking it up and carrying the eroded matter along the coast. The Needles jutting up out of the water are, of course the remnants of what was once the extremity of the promontory. No rock can resist the wearing action of the waves



The work of erosion is still going on, and in five thousand years' time more and more of the cliff will have been eaten away. The Needles will have disappeared, and the coastline will have become more or less straight, for the debris of the eroded rocks is deposited along the shore so that it fills up the bays. Just as wind and rain and river tend to level the surface of the land, so the sea tends to straighten the coastline. The dotted lines in this picture show the formation of the coast as it exists to-day

THE SHADOW AND THE SUBSTANCE

Making shadows on the wall or on a screen used to be a more frequent entertainment for boys and girls than it is to-day. The old galanty show was something like a Punch and Judy show, and the shadows of the figures were cast from inside upon the screen, which was watched by the spectators from outside. Shadows, however, are more than mere amusements, and here we read something about the science of shadows

We all know that any solid substance if it has a light behind it casts a shadow To test the matter we have only to hold up our hand between the lamp or electric light and the wall and we shall find that a shadow representing our hand will be cast upon the wall

A good deal of use has been made of this scientific principle for the purpose of entertainment Shadows on the wall if cleverly cast by different arrangements of the two hands can give much amusement, and some examples of how animals and people can be represented in shadow form will be found on page 735

Light, as we have already read on page 221 travels in straight lines and the dark shadow cast by any opaque body that is placed in the line of light is due to the fact that the light is intercepted

If a sheet of glass is held up between the light and the wall the light passes through the glass Bodies which have the property of allowing waves of light to pass through them are called transparent bodies The word "transparent" is from the Latin and means "appearing across or beyond"

But light waves cannot pass through most solid bodies, which either absorb or reflect back some or all of the light That is why we call them "opaque," which is from a Latin word meaning "shaded"

It must be remembered that the shade cast by an opaque body is not merely the dark outline which appears upon an illuminated surface as when we make shadow figures on the wall We have already seen on page 227 that a shadow is something more than this When the Moon gets between the Sun and our Earth it casts a shadow which is in the form of a cone and reaches from the Moon to the Earth's surface so that it is a cone whose diameter is 2163 miles—the diameter of the Moon itself and whose length, the apex of the cone, is sometimes as great as 238 000 miles

We have seen also, on pages 227 and 228 that when the source of light is more than mere point there is a second cone of shadow, less dark than the other, which is called the penumbra This is due to the fact that while some parts of the source of light are shut off by the dark object light rays from other parts of the source of light are not obstructed and so the penumbra or "almost shadow" is partly shade and partly illumination It is less bright than the illuminated area, and less dark than completely shaded parts

When we make shadows on the wall in ordinary daylight we shall see that there is a penumbra round the dark shadow because the source of light is so large it is the whole sky, or the whole of that part of the sky which can be seen from the window

When however, the Sun is shining brightly or we are using as the light an electric or gas lamp, or a candle flame then the source of light is much smaller, and so the shadow is darker and the nearer we get to the wall with our hands, the clearer and better defined will the shadow be This is because the closer our hands are to the wall, the less opportunity is there for diffused light to get round our hands and interfere with the shadow

But now we come to the question Does a shadow represent the substance

Plato, the great Greek philosopher, imagined men sitting shackled in a cave with their backs to the entrance and unable to turn their heads. He supposed a bright fire to be burning at the entrance and men with models of animals and people passing along by a wall, so that the shadows of the models were thrown on the side of the cave which the prisoners were facing The only knowledge of things which these people could have would be from the passing shadows The shadows, he says, would appear to them as substance, or reality

or object which casts it ? Can we judge of the shape or nature of an object by the shadow which it casts?

That a shadow might be very misleading has been recognised from very ancient times. We read in the Bible (Judges, Chapter IX, verse 36) how, when a man saw an army marching upon the city where he was, another man told him : "Thou seest the shadow of the mountains as if they were men," which shows that it was quite recognised in those days that shadows might be deceiving. At the same time, we also find in the Bible that shadows can give a very good idea of the objects that cast them. The Law, for instance, is spoken of as "having a shadow of good things to come."

We read on page 358 that one of the reasons we know the Earth on which we live is round is that it always casts a round shadow on the Moon when it gets between the Sun and the Moon ; that is, during an eclipse spectators on the other side of a semi-transparent screen. The illusion is all the greater when the hands that cast the shadows are not seen.

A great deal of fun may be obtained by making with the hands the shadows shown on the opposite page, but it adds to the interest when we know something about the science of shadows.

More than 22 centuries ago there lived in Greece a very wise man named Plato, and he had something exceedingly interesting to say about shadows. In a book which he wrote, called "The Republic," which is one of the greatest books in the world, he asks us to picture a curious scene.

The Prisoners in the Cave

"Imagine," he says, "a number of men living in an underground cave, with an entrance open to the light extending along the entire length of the cavern." Plato wants us to think of these men as having been confined from their hold the shadows of those manufactured articles to be the only realities.

"Now," continues Plato, "consider what would happen if one of them is released and compelled suddenly to stand up and turn his neck round and walk with open eyes towards the light.

"Let us suppose that he goes through all these actions with pain, and that the dazzling splendour renders him incapable of discerning those objects of which he used formerly to see the shadows. What answer should you expect him to make if someone were to tell him that in those days he was watching foolish phantoms, but that now he is somewhat nearer to reality, and is turned towards things more real, and sees more correctly ? Should you not expect him to be puzzled and regard his old visions as truer than the objects now forced upon his notice ?"

Plato then goes on to explain that if the man were taken into the sunlight he would first of all be most successful

Here are ten objects of different shapes, all of which in a certain position would cast a circular shadow. This shows how mistaken we should be if we judged of the substance by the shadow. These objects, with the exception of the ball, would in different positions cast a very great variety of shadows

No matter what position the Earth may be in—and through the centuries it has been in very many positions—it always casts the circular shadow.

But objects of many other shapes can also in certain circumstances cast a circular shadow. For instance, on this page we find ten different objects, all of which in a certain position would cast a circular shadow, and yet they are extraordinarily varied in shape. Now except in the case of the round ball the shadow would give no real idea of the shape of the object that casts it It is, therefore, both correct and incorrect to say that a shadow represents the substance. It is true that for a shadow to have a certain shape the object that casts it must in that position have the shape indicated. But it may, from the position of the object, be a very misleading shadow.

What child, for instance, who had never before in his life seen shadows on the wall, could possibly know, if he saw the shadows on page 735, the kind of objects which were casting them ? He would never dream that they were made by the human hands. That is why, at a shadow exhibition, the shadows are often witnessed by childhood with their legs and necks so shackled that they are obliged to sit quite still and look straight in front of them, because their chains make it impossible for them to turn their heads round.

He next asks us to imagine a bright fire burning some way off above and beyond them, and an elevated roadway passing between the fire and the prisoners, with a low wall built along its course.

Thinking Shadows are Realities

Plato then describes a number of persons walking behind this wall and carrying with them statues of men and animals made of wood and stone, and all kinds of materials, together with various other articles. These objects pass just above the height of the wall, and the light of the fire throws their shapes upon the illuminated wall in front of the shackled prisoners.

"Let me ask you," says Plato, "whether persons so confined could have seen anything of themselves or of each other beyond the shadows thrown by the fire upon the part of the cavern facing them." His point is that all their knowledge of things would be obtained from the passing shadows. Such persons, he says, would in distinguishing shadows, then he would discern the reflection of men and things in water, and only afterwards the realities themselves.

If the man had to return to his old place in the cave, continues the writer, and were then to describe the realities which he had seen, he would only be a laughing-stock to the other prisoners, who would declare that his eyesight was wrong, and that it was they who were seeing the realities in the shadows.

The great Greek philosopher, of course, uses this as an illustration of man's gradual groping after and discovery of realities. But it is interesting to know that so much can be learnt from thinking about shadows.

Of course, shadows are not altogether illusory or false. They sometimes serve a useful purpose, as Shakespeare suggests when he tells us that Thisbe did

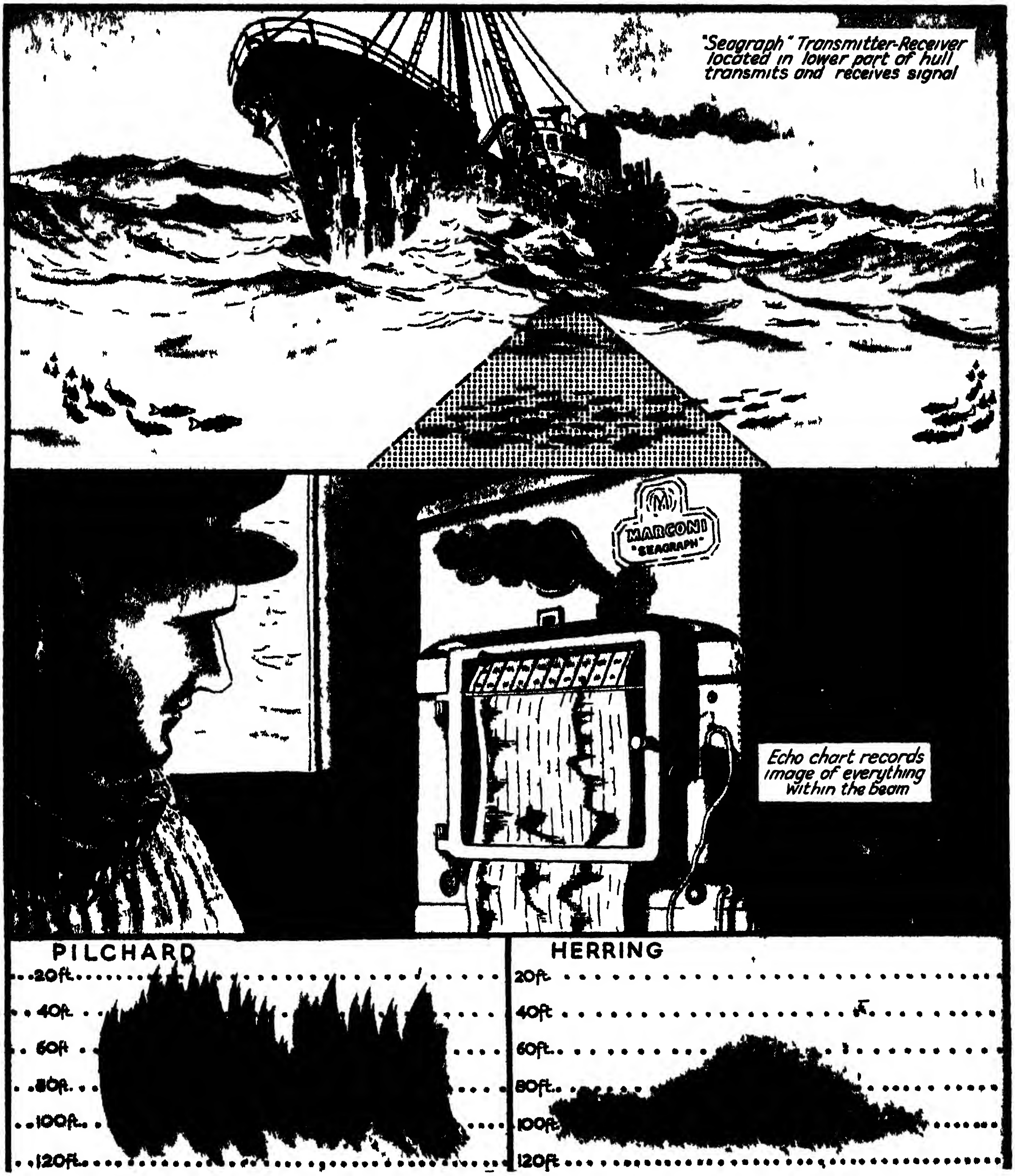
> Fearfully o'erstrip the dew,
> And saw the lion's shadow ere himself,
> And ran dismayed away.

It would be a strange world without shadows, and the disadvantage of having no shadow has been set forth with a good deal of imagination in a famous book with the title "The Man Without a Shadow."

THE STRANGE SHADOWS ON THE WALL

It is always interesting to make shadows on the wall, and the pictures on this page show how a great variety of shadows representing animals and people can be made by putting our hands and fingers in certain positions. It takes a little skill to make really good shadows in this way, but all who have patience to practise will be able to make shadows as distinct and clear as those shown here

HOW TRAWLERS FISH WITH ECHO-SOUNDERS



Once upon a time trawlers had to keep casting their nets until they found a shoal of fish With the echo-sounder a trawler finds the shoal and then casts its nets. In the bottom of the ship's hull an electric device automatically transmits sound impulses which are reflected back from the sea bed or from any obstacle between the sea bed and the hull of the ship The reflected sound is picked up by a receiver on the ship and converted into an electric current to move a pen which draws on a strip of paper the outline of the object from which the sound has been reflected The sound impulses are transmitted at intervals, so that the echo from one sound has time to be echoed back before the next sound impulse is transmitted As the rate at which an echo travels through water is known, an electrical device on the receiver calculates the depth of the echoed object In the top picture a shoal of fish has come within range of sound impulses from the trawler In the centre picture the trawler skipper is watching the echoed image of the shoal The bottom drawing shows how different fish echo different images, depending upon how closely they are swimming and the depth of the shoal.